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1379
(Medical and Chemical Series, No. 10.)
(Dyes and Tans.)

THE
AGRICULTURAL LEDGER.

1897—No. 6.

MYRICA NAGI.

[(KAIPHAL BARK.)]

[*Dictionary of Economic Products, Vol. V., M. 869-77.*]

THE TINCTORIAL PROPERTIES OF KAIPHAL BARK AND AN ANALYSIS
OF THE COLOURING PRINCIPLE.

By PROFESSOR JOHN JAMES HUMMEL and MR. ARTHUR GEORGE PERKIN. *With an
Introduction by MR. DAVID HOOPER.*

INTRODUCTION.

India is naturally rich in dyeing agents, and those of acknowledged value have been in use for so many years that it would seem superfluous to suggest changes in the industry. The introduction of aniline dyes, on account of their cheapness and ease of application, have to some extent reduced the trade in raw and bulky colouring materials; but there are still many tints obtained by the dyer in this country which cannot be imitated by artificial means. The indigenous vegetable colours are derived from plants, which, if not wild, are easily cultivated, and the Native operator in outlying districts is quite satisfied with his crude methods of dyeing passed down through many generations.

The attention that has recently been paid by experts to the different coloured dye-stuffs of India has resulted, for the first time, in an attempt to classify these articles scientifically. Mr. (now Sir Thomas) Wardle, of Leek, and Professor Hummel, of Leeds, have experimented with the dyes with regard to their technical properties, while Dr. Schunck and Mr. A. G. Perkin have elucidated the subject by their analyses of the actual colouring principles found in the raw products. As far as the yellow dye-stuffs have been investigated by

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Messrs. Hummel and Perkin conjointly, there are those applied with the aid of mordants having a similar chemical composition, while others which are applied direct are related in their tinctorial power to the constitution of their active principles. The experiments have enabled the authors to pass an opinion on the value of the dye-stuffs in European commerce and to indicate the permanent or fugitive nature of the colours obtained from them.

One of the most interesting results of the enquiry has been the discovery of a bark possessing a rich yellow colouring matter, far superior to many well-known dye-stuffs. The bark in question is derived from **Myrica Nagi** and has hitherto been collected and used for its medicinal properties which are described in Sanskrit works of great antiquity. The drug is astringent in its properties and has been used for tanning. The only reference to its use as a dye is very vague, and its properties are not known among Native traders. In the following paragraphs we have placed together all the available information on this article concluding with the exhaustive analysis recently made of the bark in England.

Myrica Nagi is an evergreen, dioecious tree belonging to the MYRICACEÆ, a small natural order of plants placed between the URTICACEÆ and the CASUARINEÆ. It is met with in the sub-tropical Himálaya from the Ravi eastward, also in the Khasia Mountains, Sylhet and southwards to Singapore, and is distributed in the Malay Islands, China and Japan.

Some confusion has arisen from the fact that the tree has been variously named by botanists, but from a thorough examination of the genus by Sir J. D. Hooker, it has been decided that the following six names refer to one and the same species—the tree under consideration :—

Myrica esculenta, Buch.-Ham.

M. Farquhariana, Wall.

M. integrifolia, Roxb.

M. missionis, Wall.

M. rubra, Sieb. et Zucc.

M. sapida, Wall.

The English name of the tree is Box Myrtle. In China it is called *Fangmæ* and in Japan *Shibuki*. *Kaiphal* is the name applied in India both to the tree itself and to the bark or portion of the tree used by the Natives.

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The bark is collected in the Himálaya at altitudes of from 3,000 to 6,000 feet, and is occasionally exported in large quantities to the plains in the North-Western Provinces and other parts of India, in recent years to the extent of 50 tons per annum. In Bombay it is worth from 1 to 2 rupees per maund of 41lb.

The bark is used as a tan for fancy leather work, and according to Mr. W. Coldstream it is used in Sirmur in the Simla District for dyeing a peculiar pink. It is also employed in medicine and is kept in stock in most of the Native drug shops in Northern India. In Sanskrit works the bark is described as heating, stimulant, and useful in diseases supposed to be caused by deranged phlegm, such as catarrhal fever, cough and affections of the throat. Like most Eastern remedies the bark is usually prescribed in the form of a mixture with other stimulants, alteratives and aromatics. Dr. U. C. Dutt speaks of the powdered bark being simply used as a snuff for catarrh with headache. *Kaiphál* mixed with ginger, according to some doctors, is the best medicine for cholera. Hindus and Mahomedans use *kaiphál* in the present day as an astringent, carminative and tonic, and prescribe it for chronic cough, fever and piles. Mixed with vinegar it strengthens the gums and cures toothache. It will be seen that it is used where astringents are required, and the dose is stated to be sixty grains of the powdered bark.

The astringent properties of this bark are not utilised in India only as they are recognised in Japan and America. In an article on a number of tanning materials used in Japan, Mr. J. Ishikawa (*Chemical News*, December 3, 1880, p. 275) gives the result of his analysis of *shibuki* bark, obtained from **Myrica rubra**, and shows that the specimens submitted to him contained from 11 to 14 per cent. of tannin.

An American species of **Myrica** (*M. asplenifolia*, L.) was examined in 1894 by Mr. C. C. Manger, who found the following maximum proportions of tannin in the moist state:—leaves, 9.42; stem, 3.72; rhizome, 5.47. In an absolutely dry state the proportions were as follows:—leaves, 10.28; stem, 4.16; rhizome, 6.00.

The bark of **Myrica Nagi**, when collected in India from large trees, is about half an inch thick, extremely scabrous, pitted from the separation of pieces of suber, of a mottled rusty brown and dirty-white colour, suber warty; substance of bark and inner surface

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of a dull red colour; it yields a red colour to water; taste strongly astringent. Examined microscopically, within the suberous layer is seen a remarkable stratum of stony cells; the parenchyma throughout is loaded with red colouring matter, and permeated with large laticiferous vessels, from which a gummy latex exudes when the bark is soaked in water. In a powdered condition it acts as an irritant on the mucous membrane of the nostrils.

A sample of *Kaiphal* from Bombay, consisting of thick pieces of bark, evidently taken from old trees, contained 11 per cent. of moisture and yielded 7 per cent. of ash. Estimated for tannin, it afforded 13.7 per cent. The lead compound of the tannic acid left when ignited 30.72 per cent. of oxide, a result which compared very closely with the amount found in the compound separated from the "kino," namely, 31.88 and 30.36 per cent. in two estimations. The tannic acid, separated from the tincture by evaporation and treatment with water, gives a bluish-purple colour with ferric chloride, but on adding this reagent to a decoction of the bark, a dirty green precipitate is formed.

Mr. H. R. Procter, Lecturer on Leather Industries, Yorkshire College, Leeds, gives the following average of four separate analyses of the bark of *Myrica Nagi*:—

Tannin matters absorbed by hide	.	.	.	27.3
Soluble non-tanning substances	.	.	.	7.9
Fibre, and insoluble matters	.	.	.	52.3
Moisture	.	.	.	12.5
				100.0

It will be observed that the variability in the amount of the tannin in these barks has a wide range. The sample examined in Leeds by Mr. Procter contained about double the amount of tannin to that purchased in the Bombay market. Like most of the astringent barks the richness of the active principle may be attributed to the age of the tree or portion of the tree, branch or stem, which afforded the sample.

In 1889, Dr. Dymock sent the writer for analysis a sample of *Myrica Kino*. This substance occurred in a granular condition; it was of a dark purplish-red colour, hard and brittle when dry, and without any peculiar odour. It dissolved almost completely in boiling water, but a flocculent red precipitate separated when the decoction cooled.

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A tincture made with rectified spirit was of a fine, bright red colour and very acid in reaction. The tannic acid gave a greenish colour with ferric chloride, and [was estimated in a cold watery infusion of the drug with a solution of plumbic acetate. The "Kino" had the following composition :—			INTRODUC- TION.
Pure tannic acid	. . . . .	60.8	
Insoluble in water	. . . . .	3.3	
Moisture . . . . .	. . . . .	9.8	
Ash . . . . .	. . . . .	10.8	
Sugar, etc. . . . .	. . . . .	15.3	
		100.0	
<p>The large amount of carbonated ash left, on incineration, points to the probability of some of the tannic acid existing in combination with a mineral base, and this was really so. A large quantity of a substance readily reducing Fehling's test, is not a usual constituent of a natural astringent secretion like Kino, and it was interesting to find that the above substance had been prepared by evaporating a watery decoction of the bark; this would account for the presence of mineral matter and glucose in the extract.</p> <p>For several years past Professor Hummel, of Leeds, has been working on the Dyes and Tans of India, and recently, in conjunction with Mr. A. G. Perkin, who has submitted each dye to a critical chemical analysis, a most valuable series of papers has been published on Indian dyeing materials.</p> <p>In a letter dated the 22nd November 1894, Sir F. A. Abel, Bart., K.C.B., Secretary and Director of the Imperial Institute, communicated to Dr. Watt some of the results of these investigations, and referring to the labours of Professor Hummel he wrote: "He also informs me that he has completed preliminary dyeing experiments with the whole of the Indian dye-stuffs in the Museum of the Yorkshire College, and he sends me a list of eight which are sufficiently rich in colouring matter to render them worthy of examination both chemically and tinctorially in preference to others. He asks whether I can obtain for him within, say, a year from this time from 1 to 2 cwt. of three or four of these materials which he names in the order of their merit of dye-stuffs."</p>			

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In the list which Sir F. Abel appended to his letter and which specifies the dyes arranged in the order of their tinctorial value, it is seen that the bark of **Myrica Nagi** takes the highest place.

1. **Myrica Nagi** (bark).
2. **Delphinium Zalil** (flowers).
3. **Carpesium abrotanoides** (whole plant).
4. **Nyctanthes Arbor-tristis** (flower tubes).
5. **Kandelia Rheedii** (wood).
6. **Gossypium herbaceum** (flowers).
7. **Thespesia populnea** (flowers).
8. **Mangifera indica** (bark).

The Reporter on Economic Products to the Government of India having supplied the required quantity of Kaiphal bark next year Messrs. Hummel and Perkin published the results of their work in this direction as far as they had gone. The paper was read before the Society of Chemical Industry, London, and printed in the Journal for May 31, 1895. It was sent as a contribution from the Cloth-workers' Research Laboratory in the Dyeing Department of the Yorkshire College, Leeds, and was entitled "The Tinctorial Properties of some Indian Dye-stuffs, Part II." The following extract gives the conclusions the authors arrive at with regard to **Myrica** :—

"The dyeing properties of **Myrica** bark, although generally similar to those of other yellow mordant dye-stuffs, differ in some respects from any one of them. On wool, with chromium mordant, it gives a deep olive-yellow, and with aluminium a dull yellow, similar to the corresponding colours obtained from quercitron bark, but much fuller; with tin mordant, however, it gives a bright red-orange, redder in hue than that given by quercitron bark, and fuller even than that given by an equal percentage of Persian berries, to which otherwise it is very similar; with iron mordant it gives a dark greenish-olive like that obtained from quercitron bark, but again fuller; it seems indeed to have a greater colouring power than all other natural yellow mordant dye-stuffs.

"On cotton with aluminium and iron mordants it dyes colours which are more similar to those obtained from old fustic than from quercitron bark, the colours with iron mordant, for example, not exhibiting the dark and bluish hue given by the latter, as though tannin matter were absent.

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" Compared with old fustic, on wool mordanted with aluminium, 3.7 grms. **Myrica** bark equal in dyeing power 5 grms. old fustic but it gives a much duller olive-yellow colour. Compared with Chromium mordant on wool, 2 grms. **Myrica** bark are equal to 5 grms. old fustic, but here, too, the colour is much redder or browner.

" The comparative richness in colouring power of **Myrica** bark, and the full, brilliant red-orange given with tin mordants on wool, are sufficiently interesting to warrant us in examining this bark thoroughly, more particularly since it is evident that its utility as a dye-stuff is unknown to the Hindus."

Sir F. A. Abel, when forwarding copies of the above paper from the Imperial Institute, on the 27th June 1895, made a request for a larger supply of the bark to allow of a complete set of experiments being carried out, and in accordance with the request about 70 lb of Kaiphal were collected by the Reporter on Economic Products in Simla and despatched to London in November.

In the course of a few months the following important paper on a full analysis of Kaiphal appeared in *The Transactions of the Chemical Society*. The paper is printed *in extenso*, with the exception of the experimental data and calculations of the formulæ:—

Contribution from the Clothworkers' Research Laboratory, Dyeing Department, Yorkshire College. The colouring principle contained in the bark of Myrica Nagi. Part I.

By ARTHUR GEORGE PERKIN and JOHN JAMES HUMMEL.

In the course of examining the tinctorial properties of some Indian dye-stuffs (*J. Soc. Chem. Ind.*, 1895) our attention was especially attracted by the behaviour of the bark of **Myrica Nagi**. Not only did the colouring power compare favourably with that of such well-known dye-stuffs as old fustic and quercitron bark, but in some respects it seemed to differ from all other yellow mordant dye-stuffs. Having subsequently received a larger supply through the kindness of the authorities of the Imperial Institute, London, the chemical examination of this dye-stuff was undertaken, and the results are recorded below.

EXPERIMENTAL PART.

The ground bark (1,000 grams) was digested for six hours with ten times its weight of boiling water, the mixture strained through

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calio, and the residue treated again in a similar manner. Experiment showed that by extracting the filtrate with ether a small amount of colouring matter could be thus obtained; the ethereal extract separated, however, with difficulty from the aqueous liquid, and as also a very large quantity of ether was necessary for this process, the following method appeared preferable. To the combined boiling aqueous extracts, a solution of 60 grams of lead acetate was added, when a bulky, yellowish precipitate was obtained, which, on prolonged boiling, became dirty white; this consisted almost entirely of the lead compound of tannin matter, and contained but a trace of colouring matter. This was removed by filtration, washed with water, and the filtrate treated with more lead acetate solution until a precipitate was no longer formed; the lemon-yellow lead compound was then collected, washed, and decomposed, while still moist, by means of boiling dilute sulphuric acid. The brown liquid, which now contained the colouring matter, was removed from the lead sulphate by decantation, and extracted twice with ether; the yellow crystalline residue left on evaporating the ethereal extract was dissolved in a little alcohol, and the solution diluted with boiling water. The crystals which separated on cooling, were collected and extracted two or three times with small quantities of boiling acetic acid in order to remove a colourless wax-like substance which was present in some quantity. By recrystallisation from dilute alcohol, the product was obtained in a pure condition. The yield of colouring matter from 100 grams of bark averaged from 0.23 to 0.27 gram.

The ultimate analysis indicated the formula $C_{15}H_{10}O_8$, which requires $C = 56.60$; $H = 3.14$ per cent.

It formed a mass of light yellow, glistening needles closely resembling quercetin in appearance, and melting above 300° with decomposition. When heated between watch glasses, the mass became carbonised, and a small quantity of yellow vapour was evolved, which, on cooling, condensed to minute needles of the unchanged substance. It is very sparingly soluble in boiling water, somewhat readily in alcohol, and almost insoluble in chloroform and acetic acid. Though closely resembling in appearance the colouring matters of the quercetin group, it is readily distinguished from those at present known by the colour changes it produces when dissolved in alkaline solutions. With dilute potassium hydroxide, a green solution is first

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formed; this, on exposure to air, rapidly assumes a deep blue tint, which in its turn gradually becomes dull red-violet. With strong alkali a fairly permanent orange-coloured liquid is obtained which, when diluted, passes through the colour changes recorded above. A solution of ammonia produced somewhat similar results, the colour obtained having, however, a redder tint. The addition of lead acetate to its alcoholic solution throws down a reddish-orange precipitate which becomes yellower on boiling. The colouring matter dissolves in cold sulphuric acid, forming a deep red solution, which deposits the unchanged substance on adding water. Its alcoholic solution is coloured brownish-black by ferric chloride. In examining the dyeing properties of this new colouring matter, for which we propose the name *myricetin*, experiments were carried out with it side by side with equal weights of pure preparations of quercetin, fisetin, morin, gentisin, and euxanthone, using woollen cloth mordanted with chromium, aluminium, and tin. It was at once apparent that a strong resemblance existed between the shades given by myricetin, quercetin, and fisetin, in fact, so similar were they, that unless placed side by side one might easily be mistaken for the other. These differences are best seen in the table.

This table shows that, so far as its dyeing properties are concerned, morin belongs to a distinct group, and the same may be said regarding gentisin and euxanthone.

By examination in Ziesel's apparatus, myricetin was found to contain no methoxyl-groups.

	Chromium.	Aluminium.	Tin.
1 { Myricetin .	Red-brown .	Brown-orange . . .	Bright red-orange.
Fisetin .	" .	Brown-orange, inclin- ing to red.	Slightly less red.
Quercetin .	" .	Brown-orange, inclin- ing to yellow.	Bright orange.
2 Morin .	Olive-yellow .	Dull yellow . . .	Bright yellow.
3 { Gentisin .	Green yellow, dull and pale.	Bright yellow tint, very pale, scarcely dyed.	Cream colour, scarce- ly dyed.
Euxanthone	Dull brown, yellow.	Bright yellow, pale.	Bright yellow, tint very pale, scarcely dyed.

Myricetin Sulphate, $C_{15}H_{10}O_8 \cdot H_2SO_4$.—In order to determine the molecular weight of myricetin, its behaviour towards mineral

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acids was studied, this method, as shown in former communications having proved of considerable service for this purpose.

The addition of sulphuric acid to myricetin suspended in boiling acetic acid caused the formation of an orange-coloured, crystalline compound, which was collected, washed with acetic acid, and dried.

It was obtained as a glistening mass of slender needles somewhat redder than the corresponding quercetin compound. By treatment with water, it is decomposed into myricetin and sulphuric acid.

Myricetin hydrobromide, $C_{15}H_{10}O_8.HBr$ is obtained in orange-red needles on adding hydrobromic acid to myricetin suspended in boiling acetic acid.

By treatment with water, it is decomposed into myricetin and hydrobromic acid.

Myricetin hydrochloride, $C_{15}H_{10}O_8.HCl$, closely resembles the above compound. When heated at 100° , it is slowly decomposed into myricetin and hydrochloric acid, and was consequently not analysed. In the instability of its compound with hydrogen chloride, myricetin resembles quercetin, fisetin, and morin (*Trans.* 1895, 67,646), but differs from that of luteolin (this vol., p. 208), which is stable at this temperature.

Myricetin hydriodide, $C_{15}H_{10}O_8.HI$, crystallises beautifully in glistening needles of a red orange colour. The above results show that the true formula of myricetin is $C_{15}H_{10}O_8$.

Hexacetylmyricetin, $C_{15}H_4O_8(C_2H_3O)_6$.—A solution of one part of myricetin and one part of anhydrous sodium acetate in three parts of acetic anhydride was boiled for one hour, the product poured into water, and, after being allowed to stand 24 hours, collected and purified by crystallisation from alcohol.

It forms a silky mass of colourless needles melting at $203-204^\circ$ very sparingly soluble in alcohol, more readily in acetic acid. It is insoluble in cold alkaline solutions. In order to determine the number of acetyl groups present in this substance, a solution in acetic acid was boiled with the addition of a few drops of sulphuric acid. Boiling water was then added, and the crystals of myricetin which separated on cooling were collected and weighed, and from an ultimate analysis the substance was proved to be a *hexacetyl* compound.

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Hexabenzoylmyricetin, $C_{15}H_4O_8(C_7H_5O)_6$.—Owing to the readiness with which myricetin decomposes in alkaline solution, the method of Baumann and Schotten was not available. Myricetin was therefore heated with excess of benzoic anhydride at $160-170^\circ$ for four hours, and the product dissolved in acetic acid and poured into alcohol. After 12 hours, a colourless precipitate had separated, which was collected, washed with alcohol, and purified by crystallisation from this solvent.

It was obtained as colourless needles, readily soluble in acetic acid, sparingly in alcohol.

Action of Fused Alkalis on Myricetin.—Myricetin was heated with ten times its weight of potassium hydroxide at $150-170^\circ$ until the melt, which was originally of an orange colour, had become brown. It was then dissolved in water, the solution neutralised with acid, extracted with ether, the extract evaporated, and the crystalline residue dissolved in a little hot water. On adding lead acetate, a yellowish-white precipitate was formed, which was collected, and washed with hot water, the filtrate being placed aside for further examination.

The lead precipitate, suspended in a little water, was decomposed by sulphuric acid, the lead sulphate removed by filtration, the filtrate extracted with ether, and the extract evaporated. The brown residue, which became crystalline on standing, was treated with a very little hot water, in which most of it dissolved, the small quantity of insoluble product being collected. This, on examination, was found to be a trace of unaltered myricetin, and it is strange that any of this substance, which is so readily decomposed in dilute alkaline solution, should have resisted the action of concentrated alkali at such a high temperature.

The filtrate, on standing, deposited crystals, which after being drained upon a porous tile and crystallised two or three times from boiling water, formed a mass of needles of a slightly brown tint, melting at $239-240^\circ$, with evolution of gas, and giving the reactions of gallic acid with ferric chloride. As, however, the reactions of phloroglucinolcarboxylic acid are very similar, according to Will and Albrecht (*Ber.*, 1884, **17**, 2103 ; 1885, **18**, 1323), it was necessary to institute further tests. It was found that the substances dyed iron mordanted calico like gallic acid, that it did not give with fir wood

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and hydrochloric acid the phloroglucinol reaction, and, further, that when heated to 240° the residue had the properties of pyrogallol, and not of phloroglucinol. It was therefore *gallic acid*.

The filtrate from the lead precipitate was treated with sulphuric acid to decompose lead compounds, the lead sulphate removed by filtration, the filtrate extracted with ether, and the extract evaporated. The residue thus obtained was too small for complete purification, but it gave the phloroglucinol reaction, and without doubt consisted chiefly of this substance.

The principal products of the action of fused alkali on myricetin are therefore *gallic acid* and phloroglucinol.

Action of Bromine on Myricetin.—To a thin paste of myricetin in acetic acid, the amount of bromine necessary for the formation of a tetrabromo-compound was added. Hydrogen bromide was evolved, and a clear solution gradually formed; this, after standing over night, was poured into about six times its bulk of water. At first crystals were slowly deposited, but after some time a small quantity of flocculent matter also separated. The product was collected and purified by several crystallisations from dilute acetic acid. As the yield obtained in this way was somewhat unsatisfactory, experiments were carried out on the bromination of myricetin suspended in carbon bisulphide at 100° . By these means the quantity of product obtained was found to be considerably increased.

It was obtained in the form of brownish-orange, prismatic needles, melting and decomposing at $235-240^{\circ}$, readily soluble in acetic acid, slightly less so in alcohol. Alkaline solutions dissolve it at first with a yellow colouration, which on exposure to air becomes red, and finally passes into dirty brown. Its alcoholic solution gives with ferric chloride a deep blue colouration. With mordanted calico, it dyes shades considerably yellower than those of myricetin itself, and more resembling those yielded by gallacetophenone.

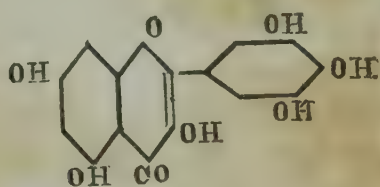
Although the analytical numbers agree closely with those required by tetrabromomyricetin $C_{15}H_6O_8Br_4$, and moreover the production of such a compound is in harmony with the probable constitution of this substance, yet on account of the peculiarity of its properties considered side by side with those of the bromine derivatives of quercetin, morin, and luteolin, some little doubt must be entertained

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as to its identity until a molecular weight determination can be carried out. By the introduction of bromine into the above colouring matters, their reactions with ferric chloride are but little altered; moreover, these compounds are considerably less soluble than the colouring matters themselves.

In examining the results of this investigation, but little doubt can be entertained that myricetin is a member of the quercetin series. Its formula, its reactions with mineral acids, and the number of hydroxyl groups it contains, when considered with the results of its decomposition with alkali, are all in harmony with this suggestion. Moreover, its dyeing properties are very similar to those of quercetin and fisetin. Before absolutely deciding its constitution, it will be necessary to examine its methyl and ethyl ethers and their decomposition products; unfortunately, the difficulty of isolating sufficient substance for this purpose may delay this investigation for some time. There appears, however, every probability that myricetin, $C_{15}H_{10}O_8$, will thus be shown to have the constitution of an hydroxy quercetin,—



Its colour reactions in alkaline solution are evidently due to the oxidation of the pyrogallol nucleus it contains.

Dyeing Properties.—The tinctorial power of the product now examined was much less than that of the small sample of bark with which the earlier experiments were made, and which had a much smoother exterior, and was labelled **Myrica rubra**; moreover, it gave somewhat different shades with the different mordants. On striped mordanted calico, the present sample gave with alumina a comparatively dull yellow, inclining to pink on a weak mordant, and with iron a purplish-grey, as if tannic acid were present. Its colouring power was much less than that of old fustic and quercitron bark. On the other hand, our former sample gave with alumina a

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full yellow, distinctly stronger, although somewhat duller, than those given by the dyewoods just mentioned, and the colour with iron mordant gave little or no indications of the presence of tannic acid. On wool mordanted with chromium, aluminium, and tin, and dyed with 40 per cent. of our latest sample, greenish-olive, olive-yellow, and yellow colours respectively were obtained, all very pale and dull, whereas with the same mordants our former sample yielded deep olive-yellow, dull-yellow, and bright red-orange, the two first reminding one of the corresponding colours obtained from quercitron bark, the latter being very similar to those given by Persian berries.

These results show either that the colouring properties of **Myrica Nagi** are somewhat variable, according to the age of the tree or branch from which the bark is taken, or that there may be different species of **Myrica**, each with slightly different tinctorial properties. The comparative richness of some of the barks, however, warrants us in directing the attention of native dyers of India to its probable utility as a yellow dye-stuff.

(Agricultural Series, No. 24.)

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1898—No. 2.

SOILS.

(INDIAN SOILS.)

[*Dictionary of Economic Products*, Vol. VI., Pt. III., S. 2260 a.]

ON THE COMPOSITION OF INDIAN SOILS.

A Note by DR. J. W. LEATHER, *Agricultural Chemist to the Government of India.*

1. The subject of Indian soils was dealt with by Dr. Voelcker in Chapter 5 of his Report, and in that chapter the following matters are discussed:—

(a) the composition of Indian soils, (b) the possible exhaustion of Indian soils, (c) the supply of nitrogen to Indian soils by rain and leguminous plants, (d) the reclamation of certain lands which have become infected by *kans* grass, eroded by surface drainage, or infertile from the presence of salts of sodium called reh.

Of these four subjects, (d) has been dealt with in *The Agricultural Ledger* Nos. 12 and 13 of 1893 and Nos. 7 and 13 of 1897, which deal with Reh and Usar, and No. 16 of 1894 describes certain methods of reclaiming Ravine Lands.

2. Regarding (c), the supply of nitrogen (ammonia and nitric acid) in the rainfall, some determinations have been made by Dr. Van Geyzel in Madras, who found in one year 4 lbs and in

Dr. Voelcker's
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Nitrogen in
rainfall.

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SOILS.

On the Composition of

Assimilation
of atmos-
pheric
Nitrogen.

another year 2.1 lbs. nitrogen per acre to be so deposited, and by Mr. Kelway Bamber at Calcutta, who found 3.39 lbs. per acre in the rainfall between May and October. The second part of this subject, namely, the assimilation of nitrogen by certain members of the natural order LEGUMINOSÆ, has been referred to in *Agricultural Ledger* No. 7 of 1894 as well as in many European journals. No work on this subject has been done specially for India; and since it is probable that the part which these plants play in relation to the supply of nitrogen to the soils of India is a very important one, a large field of very useful work remains to future investigators.

The present paper deals principally with the composition of Indian soils. Most of the information here given has been obtained during my tenure of office as Agricultural Chemist to the Government of India. For one section, however, I am indebted to Mr. Kelway Bamber's book on "The Chemistry and Agriculture of Tea," from which I have extracted the information relating to the composition of the Assam tea garden soils.

The subject of the possible exhaustion of Indian soils finds a place at the end of this note.

3. *The composition of Indian soils.*—In the opening paragraph of his chapter on soils, Dr Voelcker writes: "The soils of India have not so far been made the subject of careful or scientific study. A few analyses are recorded of the soils of particular spots, and on two of the Government experimental farms a practical analysis of the soil has been attempted by growing crops on them. Such experiments have a certain value it is true, but they fall far short of what may be gained by a systematic and scientific enquiry. Again, in paragraph 419, among the subjects which Dr. Voelcker recommends as suitable for investigation by an Agricultural Chemist, is "the sufficiencies and deficiencies of different soils in respect of the various soil constituents." Finally, in paragraph 424 Dr. Voelcker suggests that the Agricultural Chemist might usefully "assist the spread of agricultural education by the preparation of simple text-books."

It was indeed more with a view to trying to fulfil the latter recommendation than anything else, that I obtained through some of the Local Governments and others samples of typical soils, and have subjected them to chemical analysis. The completion of this work has been delayed through other duties longer than I had at first

Need for a
better know-
ledge of
Indian Soils.

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<p>anticipated, and the text book which I had hoped to prepare before the close of the present year will not have been written. The outcome of the work is, nevertheless, a fairly accurate knowledge of the composition of certain types of Indian soils ; and considering the almost total absence of any information on the subject and the need there is for it as an aid to agricultural teaching in the several agricultural colleges and schools, the matter contained in the present note will, I doubt not, prove itself of assistance to lecturers.</p> <p>Besides exhibiting the general composition of the certain classes of soils to be referred to, I have been able, I believe, to explain satisfactorily the cause of the colour of the "black cotton soil" (<i>regur</i>), which has been the subject of some little speculation.</p> <p>4. <i>Types of Soils.</i>—As pointed out in paragraph 45 of Dr. Voelcker's Report, the number of main types of soils in India is far smaller, and their position geographically far more readily defined, than is the case with those in England ; and although the variations are greater than is suggested by a mere glance at the Geological map of India, it is nevertheless true that one may divide the principal soils of this vast peninsula, which approaches the area of Europe, under about four chief heads, the soils of which are each so perfectly distinct in colour and texture from one another, and stretch uninterruptedly over such very large areas, that such a classification is not only admissible, but essential. It is not, indeed, a matter of distinguishing clays from loams and sandy soils or marls, for each of the principal Indian types of soils includes those which are more clayey and those which contain much sand or gravel, but one rather of distinguishing soils which cannot be confused the one for the other.</p> <p>The four main types of soil to be dealt with, and which certainly occupy by far the greater part of the Indian cultivated area, are the Indo-Gangetic and other alluvium, the black cotton soil or <i>regur</i>, the red soils lying on the metamorphic rocks of Madras and the laterite soils which are met with in many parts of India. There are doubtless other minor classes of soils, but they neither possess such characteristic differences in appearance, nor are they distributed over such extensive areas as the four types referred to. For instance, stretches of alluvium have been formed at the mouths of the Rivers Mahanadi, Godaveri, and others, but the area of these deltas bears no</p>	

Principal
Types of
Indian Soils.

SOILS.	On the Composition of
Minor classes of Soils.	<p>comparison to the Indo-Gangetic alluvium. Again, I found the soil covering the Dharwar system in the Dharwar District quite different from the <i>red</i> soils of the metamorphic rocks in the Madras Presidency.</p> <p>Probably a more exhaustive study of these various smaller classes of soil might be worth while undertaking. My first aim was, however, to be able to form an idea of the general constitution of the four classes named, to determine in what essential respects they differ from one another, and whether any of them may be said to be usually rich in plant food.</p>
Other soils referred to.	<p>5. In addition to an examination of these main types of soils, analyses of several other descriptions of soil have been undertaken. Ten soils of brown coloured alluvium, principally from the valley of the Cauvery, have been analysed. Six soils from a coffee estate in the Sheveroy's have also been examined.</p>
Assam Soils.	<p>From Mr. Bamber's Book on "The Chemistry and Agriculture of Tea" I have extracted much valuable information regarding the composition of the Assam Tea Garden soils.</p> <p>From these investigations it is possible to set out fairly exactly what are the chief characteristics of Indian soils generally. Several reports on the composition of soils, which constituted enquiries of a special nature, also find a place in this Note.</p>
Physical Characters.	<p>The soils of the Indo-Gangetic alluvium.</p> <p>6. It is unnecessary to define to what area the Indo-Gangetic alluvium belongs, or to say that, from Karachi on the West to Bengal on the East, one may pass without finding a single pebble; the only rocky particles larger than sand which this great expanse of land contains, is the nodular limestone which has been called "<i>kankar</i>", and which has formed by the deposition of calcium carbonate in the soil within a few feet of the surface. This large expanse of land consists generally of a yellow coloured alluvium, sometimes sandy, sometimes becoming a stiff clay, and the latter is also more of a blue-grey in places. Occasionally, too, sand <i>duns</i> or hills have been formed by the wind.</p> <p>A number of soils which are fairly representative of this alluvial area have been analysed, and these analyses are exhibited in the accompanying Statement No. 1.</p> <p>Sandy soil.—Among these soils only one (No. 20—93) is a really sandy soil. It was taken from a well cultivated field of what has been called the Ison Sand Belt in the Cawnpur District.</p>

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Sandy loams.—Two samples are of sandy loams : The one, No 22—93, is from a very fertile tract lying between the Ison and Ganges, also in the Cawnpur District ; the other, No. 339-94, is a sample of the soil of the Burdwan Experimental Farm, and may likewise be considered a typical sandy loam.

Loams.—The majority of the samples analysed are loams. The first, No. 15—93, is from the Cawnpur District, Nos. 386 & 387—95 are from the Changa Manga Fuel Plantation in the Punjab, No. 33—95 is the surface soil of the new farm at Dumraon, No. 302—96 is the mean of the analyses of two loams from the Bahr Subdivision of the Patna District.

Clays.—The three following samples were more or less clayey soils, though none of them could be considered a stiff clay. No. 41—95 is the sub-soil of the Dumraon (new) farm, No. 299—96 is a clayey soil from the Bahr Sub-division of the Patna District, No. 17—96 is a sample of the soil (surface) from the Sibpur Farm.

Calcareous soil.—Lastly, No. 127—93 is a calcareous soil from Captain Chapman's estate in the Partabgarh District of Oudh. Calcareous soils occur very rarely.

Beds of *kankar* commonly underlie both the alluvium and the *regur* ; perhaps similarly other soils. In the case of the alluvium, this *kankar* is only found mixed with the surface soil when the bed of *kankar* is very near the surface. Otherwise the surface soil of the alluvium is remarkably free from this material. In the black cotton soil (*regur*) *kankar* frequently lies in beds a few feet under the surface, but, *in addition*, small pieces of the same material are found intermixed throughout the soil, and in some of these soils the amount of calcium carbonate approaches 10 per cent.

7. Excepting in the case of the soil from Captain Chapman's estate, the largest amount of carbonic acid in any of the alluvial soils examined was 1.35 per cent. Assuming this to be entirely combined with lime, it corresponds to 3.06 per cent. calcium carbonate. The land on Captain Chapman's estate, from which the calcareous sample was taken, is a low-lying area which, until recently, was annually inundated by the river Ganges, and the large amount of lime is doubtless due to the agency of shell-fish.

Kankar.

Lime in Captain Chapman's soil.

Of these alluvial soils generally, it may be noted that the amount

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SOILS.	On the Composition of
Usually more Phosphoric acid in these soils than in other types.	<p>of phosphoric acid, though not large, is frequently more than other classes of Indian soil usually contain.</p> <p>The amount of nitrogen and organic matter varies within much about the same limits as in those examples quoted by Dr. Voelcker (paragraph 58). They are low excepting in two cases, the one being the surface soil of the Changa Manga Fuel Reserve, the other the calcareous soil from the reclaimed land at Captain Chapman's estate, and both these have been placed under conditions which are particularly favourable to an accumulation of organic matter and nitrogen.</p> <p>In other respects these soils are similar in composition to European loams and clays. The amount of iron and alumina is perhaps somewhat higher, but the divergence is not great. The sandy soil No. 20 contains $2\frac{1}{2}$ per cent. of each, and in the others the proportion rises, until in the clays it amounts to 6 or 8 per cent. of each. The proportion of magnesia, which varies from $\frac{1}{2}$ per cent. in the more sandy soils to $1\frac{1}{2}$ per cent. in the clays, is perhaps somewhat higher than in English soils generally. It is to be noted that, whilst sulphates are generally absent from the <i>regur</i>, the red soils of Madras and the laterite soils, these alluvial soils frequently contain a small amount.</p> <p>The amount of potash in those samples in which it was separately determined, varied from '16 to '66, which must be considered at least ample if not large.</p>
Nitrogen and organic matter.	
Comparison with European Soils.	
Potash.	

STATEMENT No. I.

Composition of soils of the Indo-Gangetic alluvium.

Indian Soils.													(J. W. Leather.)		SOILS.									
SANDY SOIL.			SANDY LOAMS.			LOAMY SOILS.				CLAY SOILS.			CALCA-REOUS SOIL.											
Ison Sand Belt, Cawn-pur District.			Ison Ganges, Doab.		Burdwan Experimental Farm.		Cawn-pur District.		CHANGA MANGA PLANTATION.		Dumra-on Farm surface soil.		Bahr Patna District.		Dumra-on Farm sub-soil.		Bahr Patna District.		Sibpur, Calcutta.		Partabgarh, Oudh.			
20—93.			22—93.		339—94.		15—93.		386—95.		387—95.		33—95.		302—96.		41—95.		299—96.		17—96.		127—93.	
91.72			88.08		84.31		84.84		77.03		86.06		86.82		82.96		80.90		72.64		73.58		57.52	
2.36			3.10		5.58		4.52		5.74		4.48		4.09		4.59		6.12		7.58		6.36		3.23	
2.92			4.38		6.09		5.30		4.36		4.36		4.57		5.11		6.50		9.89		7.93		3.39	
...			...		.12		...		.11		.11		.10		.11		.14		.14		.11		...	
.35			.47		.28		.91		.93		1.03		.30		1.78		2.07		1.01		1.52		14.54	
.78			.32		.66		.52		1.97		1.48		.76		1.53		1.17		1.64		1.61		1.86	
.33			.64		.56		.16		.57		.76		.48		.66		.73		.82		.64		{	
.08			.09		.04		.03		.25		.9		.08		.30		.08		.07		.11		.02	
.08			.08		.02		.10		.19		.03		Nil		.13		Nil		Nil		.03		.18	
.04			.05		.02		Nil		Nil		.47		.01		Nil		Nil		.28		1.35		.08	
.27			.37		.21		.71		.43		.47		.01		1.10		.05		.28		1.35		11.42	
1.07			2.42		2.13		2.91		8.42		1.13		2.79		1.73		2.24		5.93		6.76		7.32	
100.00			100.00		100.00		100.00		100.00		100.00		100.00		100.00		100.00		100.00		100.00		100.00	
.027			.081		.042		.046		.237		.043		.049		1.045		.041		.051		.065		.180	
Insoluble silicates and sand . . . (Fe ₂ O ₃)																								
Iron . . . (Al ₂ O ₃)																								
Alumina . . . (Mn O)																								
Manganese . . . (Ca O)																								
Lime . . . (Mg O)																								
Magnesia . . . (K ₂ O)																								
Potash . . . (Na ₂ O)																								
Soda . . . (P ₂ O ₅)																								
Phosphoric acid . . . (S O ₃)																								
Sulphuric acid . . . (C O ₂)																								
Carbonic acid . . . Organic matter and combined water (difference)																								
TOTAL . . .																								
Nitrogen . . .																								

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SOILS.	On the Composition of
Source.	<p align="center"><i>Brown alluvial soils from Madras.</i></p>
	<p>8. A number of samples of brown or greyish alluvial soils have been received from the Madras Presidency, principally from the valley of the Cauvery, and whilst they differ a good deal in colour and texture, still they may be conveniently placed in one class and described together. They are essentially different from the <i>regur</i>, the red soils and laterites, and from the alluvium of the Indo-Gangetic Plains. They appear to be free from pebbles, and although the proportion of iron and alumina is high in the loamy ones, not one of them could be considered clayey.</p>
Descriptio of samples.	<p>The Statement No. II. exhibits their composition, and the following are the descriptions which were sent with them.</p>
	<p>No. 374—96. “Brown alluvium of great depth from the bed of a ruined tank. Cholum grows nearly 20 feet high on this soil, and the stalks are chiefly used for fuel; the grain produced is more bitter than that produced elsewhere; <i>hariali</i> grass (<i>Cynodon Dactylon</i>) grown on this soil is also bitter and fetches a low price in the market.”</p>
	<p>No. 375—96. “Black loam; lies on a gravelly substratum at a depth of 2 or 3 feet; is therefore unfit for cocoa-nuts. The ryots complain that the soil of this and the neighbouring fields is not retentive enough, and needs to be more frequently watered than the fields further down the Cauvery Valley. Irrigated under the Kaling-arayan channel from the Bhavani.”</p>
	<p>No. 377—96. “Clay, black; more mellow and clayey than No. 375. At a depth of 3 to 5 feet there is a bed of impalpable black sand; cocoa-nuts and plantains thrive on this remarkably, and nowhere in the Cauvery valley are cocoa-nuts more extensively cultivated. The nuts are comparatively small.” (The sample received could not be called either black or clayey; it consisted of a dark brown loamy soil.)</p>
	<p>No. 331—96. “Red loam; this is the kind called <i>yerra masaka</i> in the Ceded Districts; locally called <i>Sempidippu karambai</i>.” The sample received consisted of a peculiarly soft dark brown soil, inclined to adhere in soft lumps. It will be noted that No. 75—96 (<i>vide</i> black soils) is also called <i>yerra masaka</i>, but the two are absolutely different in appearance and nature.</p>
<p>No. 381—96. “Loam, pale on the surface, but black below. Though entered in the Settlement Register as black clay, it is fairly S. 2260 a.</p>	

Indian Soils.	(F. W. Leather.) SOILS.
<p>friable, called in Tamil <i>palpottai</i>, produces good crops of ground-nuts, overlies a calcareous stratum at a depth of more than 5 feet.</p> <p>No. 384—96. “Loam ; retains its natural red colour ; as thin as No. 383, taken up for cultivation only a few years ago ; less fertile than No. 383.”</p> <p>No. 382—96. “Sandy soil with fine particles ; black ; uniformly friable to a great depth , has been cropped with <i>kambu</i> (<i>Pennisetum typhoideum</i>) every year mixed with ground-nuts in alternate years, <i>gingelly</i> following <i>kambu</i> in other years ; fertile.”</p> <p>No. 383—96. “Loam ; natural colour red ; but now turned grey having been manured liberally with ashes and canal silt ; overlies a bed of sandstone at a depth of 12 to 18 inches ; has been cropped with groundnuts almost every year for more than 20 years.”</p> <p>No. 385—96. “Sandy ; red soil from the right bank of the Gad-dilam river near Panruti ; has now turned grey having been plentifully manured with ashes and tank silt ; cropped incessantly with ground-nuts and <i>kambu</i> for many years ; is more than 20 feet deep and is red throughout, except near the surface.”</p> <p>No. 386—96. “Loam ; light coloured ; has turned grey having been manured plentifully with ashes and tank silt ; the soil consists of fine particles and is uniformly friable to a great depth. Has been cultivated with ground-nuts with occasional change of crops for more than 30 years.”</p> <p>Nos. 383 and 386, although described as loams, should be classed as sandy soils.</p>	<p>Description of samples.</p>
<p>9. Of these ten soils, all the loamy ones contained high, some of them very high, proportions of iron and alumina. The amount of lime is small excepting in one case, and in no case is there much carbonate of lime. The amount of magnesia is high in five of the samples. The proportion of potash, in those samples in which it was determined, is fairly high, and in no case deficient.</p> <p>Of phosphoric acid the amount is in no case large, and is in much the same proportion as occurs in the other descriptions of soil from Madras. The amount of nitrogen is as small as in most other classes of Indian soils. The amount of volatile matter is high in some cases, but this occurs principally in those soils which contain high proportions of iron and alumina, and is doubtless due to loss of combined water.</p>	<p>Iron and Alumina high.</p> <p>Potash.</p> <p>Phosphoric acid Nitrogen.</p>
<p>Judging by the descriptions they are very fertile soils, but it would appear that they are regularly manured.</p>	<p>S. 2260 a</p>

SOILS.

On the Composition of

STATEMENT No. II.

Composition of brown alluvial soils from Madras Presidency.

	LOAMS.						SANDY SOILS.			
	BELLARY DISTRICT.	COIM-BATORE DISTRICT.	TRICHINOPOLY DISTRICT.		SOUTH ARCOT DISTRICT.		SOUTH ARCOT DISTRICT.			
	Hospet Taluk.	Erode Taluk.	Kalitalai Taluk.	Perambalur Taluk.	Chidambaram Taluk.	Cuddalore Taluk.	Cuddalore Taluk.			Villupuram Taluk.
	374—96.	375—96.	377—96.	331—96.	381—96.	384—96.	382—96.	383—96.	385—96.	386—96.
Insoluble silicates and sand	57.62	78.46	75.79	66.03	82.33	77.09	95.04	87.61	96.01	93.71
Iron (Fe ₂ O ₃)	17.30	4.84	7.12	10.33	4.84	8.27	2.05	3.46	1.65	2.68
Alumina (Al ₂ O ₃)	10.23	7.97	7.86	15.28	5.85	10.60	1.06	3.89	.90	1.12
Manganese (MnO)	.26	.07	.07	.20	.09	.05	.04	.06	.03	.04
Lime (CaO)	.58	.38	.44	1.23	.32	.05	.15	.10	.09	.18
Magnesia (MgO)	1.82	1.23	1.54	1.87	1.04	.21	.51	.26	.20	.33
Potash (K ₂ O)	.27	.43	.19	.28	.98	.10	.03	.11	.07	.09
Soda (Na ₂ O)	.38	2.42	.14	.07	.06	.06	.03	.16	.04	.04
Phosphoric acid (P ₂ O ₅)	.10	.09	...	.08	...	...	...	.10	...	...
Sulphuric acid (SO ₃)	...	...	...	...	...	...	.13	...	.14	.09
Carbonic acid (CO ₂)	.16	.03	.03	.08	.06	.09	.09	.09	.09	.09
Organic matter and combined water	11.28	4.08	6.82	4.55	4.43	3.34	.96	4.16	87	1.72
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Nitrogen	.091	.105	.057	.046	.017	.008	.010	.009	.023	.019

Indian Soils.	(J. W. Leather.)	SOILS.
<p style="text-align: center;">REGUR OR "BLACK COTTON" SOILS.</p> <p>10. With two exceptions the soils referred to in the accompanying Statement are all true <i>regur</i> of good quality; the soil from Coimbatore, No. 292—94, and No. 114—95, from Anantapur, are a <i>bit</i> gravelly. The following are the descriptions which accompanied the samples.</p> <p>No. 380—96. "Black loam; one of the four classes of black cotton soil recognised in Madura and Tinnevely. It is called <i>Veppal</i>. The characteristics are a pale white colour of the surface and such an open texture that it is not fairly retentive. Is several feet deep and rests on <i>kankar</i>."</p> <p>This is a sample of good <i>regur</i> and contains small bits of white <i>kankar</i>. It is not clear how the land can have a white colour.</p> <p>No. 329—96. Madura District, Terumanyalum Taluk. "Black clay; though there had been no rain for a long time, there was moisture 9 inches below the surface."</p> <p>No. 330—96. Madura District, Terumanyalum Taluk, "Black clay; this is the same as what is called <i>Choudu regada</i> in the Ceded Districts, but not quite so hard."</p> <p>No. 332—96. Trichinopoly District, Perambalur Taluk. "The soil is a black loam not injured by heavy rainfall." (Although this soil is described as a loam, it has all the characteristic appearances of a good "<i>regur</i>", and the analysis shows that its composition coincides with the other "<i>regurs</i>". The proportion of iron and alumina, though somewhat high, is not exceptional, and the amount of lime normal, as is likewise the nitrogen and organic matter; the proportion of phosphoric acid is very small. I have therefore placed it among the good <i>regur</i> soils.</p> <p>No. 292—94. Coimbatore District, Coimbatore. This soil is a true <i>regur</i>, but somewhat less coherent than most.</p> <p>No. 114—95. Anantapur District. This is described as "Rather inferior black soil". It is also somewhat gravelly and less coherent than most.</p> <p>No. 248—96. Anantapur District, Gooty Taluk, "<i>Regur</i> clay; Nalla Regadi or pure black cotton soil."</p> <p>No. 72—96. Kistna District, Guntur Taluk. "<i>Regur</i> clay (<i>Banka regada</i>); known locally as <i>Kullu regada</i>, literally rotting regada. It is so retentive of moisture, that crops thrive on it only in years of moderate or deficient rainfall; contains small pieces of limestone</p>		<p style="text-align: center;">Description of Samples.</p>
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SOILS.

On the Composition of

Descriptions
of Samples.

called in Telugu 'Guvarayi'. The larger the proportion of the limestone, the worse the soil is held to be."

No. 73—96. Kistna District, Guntur Taluk. *Regur* clay (*Banka regada*); called locally *Pulludu regada*, literally sour regada. Requires more rain for the successful cultivation of crops than "*Kullu regada*". Contains a larger proportion of "*Guvarayi*". (As a matter of fact the sample received did not contain a larger amount of "*Guvarayi*" limestone, but just about as much as No. 72, to which this comparative remark has reference.)

No. 76—96. Krishna District, Sattenapalle Taluk. "*Regur* clay; the soil is remarkably hard, does not crack in summer so much as the ordinary black cotton soil. Does not easily get softened by immersion in water. Agricultural implements are worn out comparatively soon. Indigo leaf, produced from this sort of soil, gives as a rule a larger proportion of dye than that produced elsewhere. Requires plenty of rain for the successful cultivation of crops."

(So far as the eye could tell, this soil was a good *regur* of normal quality, and contained but little *kankar* limestone; the analysis is also quite normal.)

No. 77—96. Kistna District, Narsaraopet Taluk. "*Regur* clay; *Krishna regada*."

No. 78—96. Kistna District, Narsaraopet Taluk. "*Regur* clay; *Pulludu regada*. There is scarcely any *guvarayi*."

No. 80—96. Kurnool District, Cumbum Taluk. "*Regur* clay; locally called *Nalla or Krishna regada*."

No. 247—96. Kurnool District, Ramallakot Taluk. "*Regur* clay; cracks much in the dry weather; known as *Accha regadi* or pure black cotton soil."

No. 249—96. Kurnool District, Pattikonda Taluk. "*Regur* clay; a clay soil called locally *Marabhumi*, very hard but retentive of moisture; fertile."

No. 252—96. Cuddapah District, Pulivendla Taluk. "*Regur* clay; called locally *Banka regadi* (that is black clay soil); the cracks were wide and deep."

Nos. 276—96 and 277—96. Nagpur. This is the soil of a plot at the Experimental Farm which has not been manured for a long period of years. A crop of wheat (averaging some 600lbs. of grain per acre) has been taken off it for 12 years.

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<p>11. It will have been observed that in several instances the same vernacular name is applied to two or more of the samples. For example, Nos. 73 and 78—96 from the Kistna District are both called <i>pulludu regada</i>; No. 73 is said to contain “a larger proportion of <i>guvaraya</i> (<i>kankar</i>) than <i>Kullu regada</i>”, whilst No. 78 is said to contain “scarcely any <i>guvaraya</i>”. In appearance the samples were notably different from one another. The analysis shows that No. 73 contains scarcely any calcium carbonate; No. 78 contains a fairly high proportion. No. 72—96 is described as “<i>banka regada</i>, known locally as <i>kullu regada</i>; No. 73 is called <i>banka regada</i>, known locally as <i>pulludu regada</i>. The former is said to be “so retentive of moisture, that crops thrive on it only in years of moderate or deficient rainfall”, whilst No. 73 is said to require “more rain for the successful cultivation of crops than <i>kullu regada</i>.”</p> <p>One might have expected some difference in the composition of these two soils, such as less iron and alumina or more <i>kankar</i> in No. 73, but such is not the case; the composition of the two is as nearly alike as possible.</p> <p>No. 252—96 is also called “<i>banka regadi</i>”, but this soil has a composition widely divergent from Nos. 72 and 73.</p> <p>No. 77—96 is described as “<i>krishna regada</i>”, No. 80—96 as “<i>Nalia</i> or <i>Krishna regada</i>”, and No. 248—96 as “<i>nalla regadi</i>”. In composition No. 248 is similar (except in the amount of alkalis) to No. 77, but No. 80 differs considerably from them in several respects.</p> <p>Thus it would seem that these terms are not related at all to the chemical composition of the soils. Doubtless to the people they have a comparative significance, but if this be so, it is probable that they are related to certain physical peculiarities dependent as much on the nature of the subsoil or drainage as upon anything else.</p>	<p>Comparison of Vernacular names.</p>
<p>12. If the analyses of these 18 <i>regur</i> soils be examined, it will be seen that there is comparatively but little variation in their composition. In fact, it is remarkable how uniform their composition is. The individual constituents may with advantage be examined.</p> <p>Insoluble silicates and sand.—One sample contained only 56 per cent., and two others with appreciably less than 65 per cent.; there is only one which contained more than 75 per cent.; 14 samples contained proportions lying between 65 and 75 per cent.</p>	<p>Uniformity of composition of Soils.</p> <p>Silicates low.</p>

SOILS.	On the Composition of
Iron high.	<p>Oxide of iron.—The majority of the samples contained from about $5\frac{1}{2}$ to $8\frac{1}{2}$ per cent. One sample contained only 4·3; the Nagpur sample contained over 11 per cent., and the one from Trichinopoly District 9·2, but these appear to be extreme limits.</p>
Alumina high.	<p>Alumina.—The greater number of the samples contained from 8·5 to 11 per cent., of alumina. Two samples had only 6·3 and 6·8 respectively, whilst in four others there was 11·8, 12·0, 12·7 and 13·7 per cent., the extreme variation being about the same as in the case of iron. In all the Madras samples there was more alumina than iron by about 1 or 2 per cent. In the Nagpur sample the reverse is the case.</p>
Amount of lime varies.	<p>Manganese.—The amount of this constituent is very constant, the lowest amount found being ·09, the highest ·26. In two cases the amount is less than ·12, and in one case it was ·26, but all the other samples contained amounts varying from ·12 to ·25 per cent. of manganese. In the statement of analysis the manganese is entered as manganous oxide. It may be that some part of the manganese exists as dioxide, which I have at least once found in an Indian soil, but the amount of dioxide is certainly not great, and in the presence of organic matters such small quantities are difficult or impossible to detect.</p> <p>Lime.—The proportion of lime varies in the samples considerably not only in its total amount, but also in the condition in which it exists.</p> <p>With one exception it exists in part as carbonate and in part as silicate. In those samples in which there is 2 per cent. or more CaO, the greater part is carbonate; where, however, the total amount of lime is less than about 2 per cent., the greater part exists as silicate. They generally contain from 2 up to 4 or 5 per cent.</p>
Magnesia high.	<p>Magnesia.—The amount of magnesia is high in all samples, and varies from 1·3 to as much as 3·1 per cent. In two samples there is appreciably less than 2 per cent., and three in which it is more than $2\frac{1}{2}$ per cent., namely, 2·6, 2·7 and 3·0; in the remainder of the samples the variation falls between the limits of 2 to $2\frac{1}{2}$ per cent.</p>
Alkalis vary.	<p>Alkalis.—The alkalis vary very considerably, the lowest proportion being ·15 per cent., the highest 2·44 per cent. The amount is, however, in the majority of samples unusually large. In those samples in which the potash was separately determined, it was present</p>

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<p>in ample amount for all agricultural purposes and above what is generally found.</p>	
<p>Phosphoric acid.—The amount of this valuable plant food is small in nearly all cases. One sample contained .19 and another .23 per cent., but in all the remainder the proportion fell below .1 per cent., and in many cases much below this figure.</p>	<p>Phosphoric low.</p>
<p>Carbonic acid.—The carbonic acid exists in combination with the lime, and varies to a greater extent even than does that constituent. Apparently the carbonate of lime agglomerates together not only as <i>beds</i> of <i>kankar</i>, but also as quite small lumps of this material. At any rate many of these soils contain small round bits of <i>kankar</i> about the size of mustard seed.</p>	<p>Kankar commonly present.</p>
<p>Sulphuric acid.—Most of the samples contained no sulphates, and in no case was the amount anything appreciable.</p>	<p>Generally no Sulphates.</p>
<p>Nitrogen.—The amount of nitrogen is very small, as is common to Indian soils generally. The smallest amount is .012 per cent., the highest .050 per cent.</p>	<p>Little Nitrogen.</p>
<p>13. Organic matter and combined water.—The loss in weight which soils experience when heated moderately is occasioned by the combustion of the organic substances, the expulsion of water chemically united with the minerals of the soil, and possibly a little carbonic acid from the calcium carbonate; this latter, however, does not form any material part of the loss. It would of course be interesting to know the amount of organic carbon present apart from the “combined water”, but this had to be left undone. A conclusion may nevertheless be drawn concerning its amount. The proportion of “organic matter and combined water” is higher than in most Indian soils.</p>	<p>Loss of weight when burnt.</p>
<p>Among the soils representing the Indo-Gangetic Alluvium, one from Changa Manga contained 8.42, and the calcareous soil from Partabgarh 7.32 per cent., but in these the loss was principally due to <i>organic matter</i>. Two of the clays suffered about 6 per cent. of loss on heating, which was probably mainly due to combined water. Among the laterite soils, Nos. 284, 285 and 358 suffered considerable loss on heating, principally owing to the presence of large amounts of <i>limonite</i> which gives up its one molecule of water when heated.</p>	<p>Other classes usually lost less than <i>Regur</i>.</p>

SOILS.	On the Composition of
Loss of weight of <i>Regur</i> usually high, but not due to organic matter.	<p>Among the <i>red soils</i> from Madras one sample suffered a loss of 7·4 per cent., due principally to combined water. Generally, however, these three types of soils suffered very considerably less loss on heating than did the <i>regur</i> soils.</p>
	<p>On the other hand, when these latter are heated, the loss is almost uniformly high, but there are no indications of any particularly large amount of organic matter. They simply change colour from black to a dark brown. If a soil contain any notable quantity of humus, its combustion can be unmistakably observed.</p>
Reasons.	<p>The proportion of nitrogen is as low in most of these <i>regur</i> soils as in other soils which lose only $\frac{1}{2}$ or $\frac{1}{3}$ as much when heated. Thus the nitrogen indicates a low proportion of organic matter.</p>
	<p>Thirdly the manner in which these <i>regur</i> soils contract on drying indicates a high proportion of hydrated ferric oxide or alumina, and either of these compounds would lose the water of "hydration" on being heated. The amount of combined water then must be necessarily much higher in these soils than in ordinary ones. A further point may be referred to, namely, that soils, whether in India or elsewhere, which contain a high proportion of organic matter, possess a peculiarly dark brown appearance, approaching black, but nevertheless quite different from the colour of <i>regur</i>. Thus it appears certain that the greater part of the loss which these <i>regur</i> soils experience when heated is due to expulsion of combined water, and that there is as little organic matter in them as in most other descriptions of Indian soils.</p>
Fertility of <i>Regur</i> .	<p>14. Reference may also be suitably made in this place to the question of the fertility of <i>regur</i>. At page 412 of the <i>Geology of India</i> it is stated that "the fertility of this soil is so great that some of the black soil plains are said to have produced crops for 2,000 years without manure, without having been left fallow, and without irrigation." As to the period named, I do not suppose that Mr. Oldham, when reproducing this statement, assumed there was sufficient evidence to prove that the history of any field is so accurately known that its agricultural treatment can be traced for even as many hundreds of years. But still there is a general belief that these soils are immensely fertile. As to the origin of such a belief, it seems to me that it is due possibly to the fact that the <i>regur</i> is usually a more fertile soil than those others which frequently adjoin it, such as the</p>
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red soils, which are certainly in many cases light gravelly soils, with rock not far from the surface. The power which *regur* has of retaining moisture is so great, that on this account alone it possesses an advantage over these gravelly red and brown soils situated within the same region as the *regur*.

Then again one of the results of the strongly contracting power of *regur* is not only that it forms deep and wide fissures in the land, but also the surface literally crumbles to a coarse powder, and a part of this is annually carried by the agricultural implements, the *bakhar* for example, into the fissures, and consequently there is constantly going on an *inversion* of the soil, and what has been subsoil comes to the surface.

These two properties must naturally assist in helping the soil to produce crops. But so far from it being the case that *regur* is inordinately rich, it has been pointed out that, in the matter of phosphoric acid and nitrogen, it is very poor indeed, and if other Indian soils are as poor or even poorer in these particulars than *regur*, one cannot for a moment call it a soil of inexhaustible fertility.

The outturn of crops too at the Nagpur Farm on unmanured land is lower than on similar unmanured land of the Gangetic alluvium.

15. In the *Geology of India* (2nd edition), page 411, several analyses of black soils are given. The one made by Dr. Macleod (if even approximately correct) is of a soil very different not only to the samples which I have examined, but also to those the analyses of which are published in the same place. The seven other analyses by Mr. Tween are in some respects in fairly close agreement with mine. The undried soil was employed, and, if the mechanically contained water (7 to 10 per cent.) be withdrawn from the analyses and the remaining items calculated for 100 per cent., the figures would become comparable with mine. The silica varies between the same limits as it did in my samples. The iron and alumina *taken together* are also present in similar amount; but whilst in most of the samples which I analysed there was rather more alumina than iron, in Mr. Tween's analyses there is more iron than alumina in the soils from Seoni and Indore, the other two containing reverse proportions. The proportion of calcium carbonate too is similar. Mr. Tween left magnesia, alkalis, and phosphoric acid undetermined. The amount entered as "organic matter" must have been determined by heating

Effect of the
fissures.

Experience at
Nagpur.

Other published
analyses
of *Regur*.

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the soil, since there is no other method available, and thus the combined water is included ; this item also agrees with what I found.

I have thought it desirable to go into these analyses somewhat in detail, because on their evidence it has been assumed that "there appears always to be a considerable quantity of organic matter combined. The black colour appears to be due either to the carbonaceous elements of the soil or to organic salts of iron". As to there being any inordinate amount of *organic* matter in black soil, I have already shown that there is no evidence in *support* of such a conclusion, but rather much which is antagonistic to it. The second of the above assumptions, namely, that the colour is due to the presence of "organic salts of iron", is one difficult to discuss. It was once suggested to me that the black colour of *regur* was due to the presence of some plant which produced a dye from the root! Such a plant has never, so far as I am aware, been found anywhere. Supposing, however, that such had happened, it is true that a quantity, so small as not to materially increase the proportion of "organic matter", *might* have produced the result. But not only is this a mere assumption, there is, in addition, much evidence of a conflicting nature.

It is well to bear in mind that these *regur* soils have two peculiarities: the one being the colour, slaty-black to very dark brown-black, the other, the unusual degree to which they contract on drying. The colour of the land frequently varies more or less ; sometimes it appears quite *grey*, but this is obviously produced by the presence of *kankar* ; sometimes it appears *brown* on the sides of cuttings. But I am convinced that there *is* some constant ingredient of these soils which *is* either black or slaty-black. It *may* be that the black coloured ingredient and the ingredient which causes the strong contraction on drying are identical ; it is much more probable that they are *not*. Now, referring to the possible presence of "organic salts of iron", it must be remembered that at the high temperature (often 50°—60° C. or 120°—140° F.) to which the surface soil is subjected in India during long months each year, oxidation *must* be rapid, and doubtless is so, and one cannot imagine any organic salt of iron remaining unoxidised for generations under such circumstances.

Again, supposing some particular plant were constantly producing a dark coloured material, how comes it to do so only in *the* soil which contracts so peculiarly ? Our knowledge of plants is that they

Assumed high proportion of organic matters.

Salts of iron.

Suggested presence of organic dye.

Peculiarities of *Regur*.

Organic salts of iron can hardly be present

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do *not* exclusively grow on some particular soil. Thus it is difficult to conceive that the colour is due to organic matter at all.

At page 414 of the *Geology of India* reference is made to Mr. Blanford's paper (*Memoirs IV.*) in which he states that he found *regur* being formed in lagoons by the sea. In a foot-note at page 135 of *Memoirs IV.* (2) Dr. King states that the "*regur*" described by Blanford was not true *regur*.

Geologists' opinion as to formation of *Regur*.

Again, in the same paragraph of the *Geology of India*, reference is made to Mr. Blanford's paper (*Records VIII.*), in which he points out the similarity between the mud at the mouth of the Tapti and the *regur* of the neighbouring country, and for geological reasons assumes that the former is now being formed, and that the latter was originally formed *by the sea*. I have also seen the same country, and I must say that it appeared to me that the black mud at Surat was simply the silt brought down by the Tapti from the neighbouring *true regur*. The flow of the river is stopped at Surat by the tide, and the mud has an opportunity to deposit itself.

Tapti mud.

Messrs. King and Foote concluded that *regur* was formed in marshes; that the now high lying *regur* was originally submerged. Here again this seems to be a conclusion not warranted by facts. It is true that the mud of marshes in Europe or *jhils* in India is usually dark coloured, a colour due in many cases to organic matter and sometimes to ferrous oxide, or again to the clay being itself grey coloured, but unless due to ferrous iron, the organic matter of marshy land produces a soil of a much lighter brown colour than any true *regur*; the presence of free ferrous oxide is quite out of the question; and lastly the clayey deposits usually formed in *jhils* never has the same black colour nor the extremely high contraction which *regur* possesses.

Mud of marshes and *jhils*.

16. In my opinion one *must* come to the conclusion that the colour of *regur* is *not* due to organic matter. It is much more probable that *regur* has been formed from some particular rock which, on decomposition, forms not only a highly argillaceous soil, but also during disintegration liberates a black or very dark coloured *mineral*. Many geologists have contended that *regur* is the product of the decomposition of trap rocks. Oldham (page 413, *Geology of India*) says this view cannot be maintained because (1) "basalt generally decomposes into a reddish soil quite different from *regur* in character,"

Colour of *Regur* not due to organic matter.

SOILS.	On the Composition of
Several products of Basalt.	<p>(2) he considers that Hislop's view, that the colour of <i>regur</i> is due to impregnation of organic matter, is the most probable theory. One must of course admit that basalt is decomposing, at least in places, into a red soil, and what is still more puzzling is the fact that, whilst one finds this the case on the steep slopes of the hill-sides, it is just as common to find that <i>immediately</i> at the foot of these same slopes comes the true <i>regur</i>. Another point may advisedly be borne in mind, namely, it appears to be admitted that <i>some</i> of the <i>laterite</i> has been formed from trap. It is clear that <i>some</i> trap is decomposing into a red soil entirely different from laterite, and consequently if trap can produce two soils so different as these, why should not some descriptions of trap produce the <i>regur</i>.</p>
Indian soils usually contain little organic matter.	<p>17. I have referred to this subject somewhat at length principally because I believe there is <i>no</i> reason for assuming the colour of <i>regur</i> to be due to organic matter ; that on the contrary there is every reason for assuming such to be impossible. Not only is the amount of organic matter in <i>regur</i> always small, but in no soils from the <i>plains of India which have been regularly exposed to the sun's influence for a considerable time</i> have I found even what is in Europe generally considered an ordinary amount of humus.</p>
Exceptions.	<p>One soil from Oudh, which until recently was annually submerged by the Ganges, and which has now been reclaimed, contained probably a considerable amount of organic matter ; the surface soil from the Changa Manga plantation naturally also contained a good deal of humus, but these are cases of soils having been regularly placed under protective circumstances. Again, the coffee soils from the Sheveroy Hills contained likewise high proportions of the same material, but the temperature in that situation is much below what is common to the plains, and the land is regularly manured and also protected by the shade of the bushes.</p>
Regur contains dark coloured mineral.	<p>And if the colour of <i>regur</i> is not due to organic matter, it <i>must</i> be due to the presence of some <i>mineral</i> substance. As a matter of fact <i>regur</i> does contain a dark coloured mineral which I have reason to believe is peculiar to this soil. If <i>regur</i> be <i>boiled</i> with concentrated sulphuric acid for several hours, the insoluble residue is very dark brown. I noticed this peculiarity during the process of determining the nitrogen (the first step of which consists in boiling the soil with concentrated sulphuric acid). I have had portions of a number of</p>

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the Indian soils treated in this manner, specially to note the colour of the silicates insoluble in sulphuric acid, and the following are the notes I made. All were treated in precisely the same way, namely, 10 grammes of the soil was simply boiled with concentrated sulphuric acid for several hours. After cooling water was added and the sand washed by decantation. The colour of the latter was then noted. In the case of Nos. 329, 330, 332, 292, 248, 72, 73, 77, 78, and 249, all good *regur* soils, the silicates were almost entirely very dark brown or black coloured, and white silicates could only be seen with difficulty. Of the soils from the Indo-Gangetic alluvium, the silicates of the Changa Manga soil were nearly entirely white; those of the Burdwan soil were nearly entirely white, but included some little black silicates, the Bahr clay soil contained a good deal of black silicates; that of the Dumraon soil was nearly all white, but included a little black silicate. Among the laterite soils the silicates had the following colour: No. 282 mostly white, little black; No. 218, mostly white, some red; No. 280 mostly white, some red; No. 284, mostly dark red. The red colour of these "silicates" was quite different from the dark brown of the *regur* soils, and could not be for a moment mistaken for it. The red soils from Madras Presidency yielded silicates of the following colour: Nos. 327 and 291 mostly white, with a little black; No. 74 mostly white with some red and black; No. 333 mostly white with some red (like the silicates of laterite); No. 250 contained a good deal of black, and No. 321 mostly black. Thus, whilst some of the other soils contained insoluble silicates of a colour similar to that of the *regur* soil, the amount in such cases was always small, whilst, as already observed, the insoluble matter of the *regur* soils was almost entirely very dark brown.

It need hardly be pointed out that during the process of *boiling* the soil with sulphuric acid all organic matter is destroyed, and that the colour of the resulting "silicates" cannot be due to organic matter or to "organic salts of iron."

Colour of
silicates of
different
Indian soils.

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On the Composition of

STATEMENT No. III.
Analyses of Black Soils (Regur).

DISTRICT.	MADURA DISTRICT.			TRICHINO- POLY DISTRICT.	COIM- BATORE DISTRICT.	ANANTAPUR DISTRICT.	
	Teramanyalam Taluk.					Gooty.	
Taluk.	380-96	329-96	330-96	332-96	292-94	114-95	248-96
Insoluble silicates and sand	72.68	68.97	72.89	65.16	69.31	78.50	62.15
Iron (Fe ₂ O ₃)	6.09	6.96	6.27	9.27	5.31	4.34	6.25
Alumina (Al ₂ O ₃)	8.39	10.84	10.84	13.76	8.51	6.33	12.06
Manganese (MnO)	.19	.22	.20	.25	.20	.21	.15
Lime (CaO)	2.42	1.96	2.20	2.18	4.62	2.00	5.35
Magnesia (MgO)	1.86	1.90	2.01	2.47	2.44	1.95	2.50
Potash (K ₂ O)	.16	.26	.23	.14	.47	.43	.21
Soda (Na ₂ O)	.07	.03	.37	.01	1.00	.26	.06
Phosphoric acid (P ₂ O ₅)	Nil.	.03	.02	Trace	.19	.03	.03
Sulphuric acid (SO ₃)	2.00	Nil.	.01	Nil.	.06	Nil.	.58
Carbonic acid (CO ₂)	6.14	.25	1.09	.91	2.77	1.71	3.58
Organic matter and combined water (difference)		8.61	3.87	5.85	5.12	4.24	7.66
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Nitrogen	.019	.030	.025	.024	.027	.016	.043

STATEMENT No. III.—continued.
Analyses of Black Soils (Regur).

Ledger.

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DISTRICT.		KISTNA DISTRICT.				KARNOL DISTRICT.			CUDDA- PAH DIS- TRICT.	CENTRAL PROVINCES.		
Taluk.		Guntur.	Guntur.	Sattena- palle.	Nar- saraopet.	Nar- saraopet.	Cum- bum.	Ramal- lakot.	Patti- konda.	Puli- vendla.	Surface soil.	Sub-soil.
		72-96	73-96	76-96	77-96	78-96	80-96	247-96	249-96	252-96	276-96	277-96
Insoluble silicates and sand		72-32	71-66	70-68	64-92	68-29	71-94	63-74	64-91	56-68	68-71	67-01
Iron (Fe ₂ O ₃)		6-67	6-64	7-04	6-60	6-96	5-60	6-54	6-33	8-74	11-25	11-50
Alumina (Al ₂ O ₃)		8-50	8-74	10-61	10-91	10-20	8-62	11-83	9-99	12-77	9-39	10-41
Manganese (MnO)		1-14	1-12	1-18	1-10	1-09	1-12	1-16	1-16	1-22	1-26	1-25
Lime (CaO)		1-44	1-16	1-67	3-53	3-43	3-31	3-66	4-90	4-95	1-82	1-76
Magnesia (MgO)		2-06	2-39	2-02	2-55	2-67	1-94	2-78	2-35	3-09	1-79	2-19
Potash (K ₂ O)		1-68	1-48	1-68	1-79	1-14	1-64	1-43	1-28	1-67	1-45	1-50
Soda (Na ₂ O)		1-31	1-06	1-21	1-57	1-30	1-08	1-21	1-05	1-08	1-06	1-01
Phosphoric acid (P ₂ O ₅)		1-07	1-06	1-05	1-07	1-08	1-08	1-05	1-07	1-08	1-06	1-05
Sulphuric acid (SO ₃)		Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.
Carbonic acid (CO ₂)		1-16	1-16	1-49	1-96	1-88	2-40	2-32	3-15	3-43	1-44	1-53
Organic matter and combined water (difference).		7-65	8-59	6-37	8-00	3-96	5-35	8-28	7-80	9-37	5-83	5-79
TOTAL		100-00	100-00	100-00	100-00	100-00	100-00	100-00	100-00	100-00	100-00	100-00
Nitrogen		0-49	0-36	0-20	0-30	0-12	0-45	0-34	0-35	0-28	0-50	0-04

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On the Composition of

18. After obtaining the results here detailed regarding the composition of the *regur* soils, I submitted a copy to the Director of the Geological Survey, and I add here copies of Mr. Oldham's letter on the subject and my reply.

Copy of a Demi-official letter dated 3rd September 1897, from Mr. Oldham to Dr. J. W. Leather.

Correspondence with Mr. Oldham.

"I return herewith the extract from your report on *regur* with thanks for the favour of being enabled to see it. I trust you will arrange that we are supplied with a copy when printed. As regards your ideas, it is of course impossible to judge fully from a mere extract. To take one point only, I think, from what I have seen, that the dark colour is not due to humus, but an important element in deciding this is the determination of the amount of organic carbon in the soil. From the extract you send it would seem that this was not determined, but this is probably in another part of the report.

The following points, however, struck me :—

(1) With a single exception, none of your samples came from the typical *regur* areas of the Deccan trap plateau in Bombay, Berar and Malwa. The one exception, the sample from Nagpur, is from the extreme limit of the area. The identity of the Madras cotton soils with the true *regur* has been doubted, and as it is to the latter, as developed in the plateau of the Deccan trap, that the Manual principally refers, some of your criticisms are easily explained.

For instance, the divergence you notice between Tween's analyses and yours is due to this. In the districts where his analyses show an excess of iron over alumina, this is, I should say, a general feature, and is in agreement with your single analysis.—Nagpur,—from the same region. The Madras cotton soil I would expect to contain less iron if they agree with the other in mode of origin.

The remark in the Manual about the fertility of the soil has special reference to the region from which you have no samples. I think it is probable that the general impression which it records is explicable as you explain it, but there can be no doubt of the general idea as to the fertility of the soil, an idea which is crystallised in the term Malwa, applied to the great spread of it north of the Nerbada.

(2) Though I think it probable that the dark colour is not due to humus, it might yet be due to organic matter, as organic acids in combination with ferrous salts give dark-coloured compounds—

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e.g., ink—and a soil composed of decomposing basic minerals would naturally contain ferrous compounds.

(3) The concluding part of your extract is, I must confess, inexplicable to me, for I know of no dark-coloured silicate whose specific gravity is less than any white silicate, and unless our accepted ideas of chemical and physical constitution are erroneous, do not see how such could be the case. It seems clear that the particles with which you were dealing could not be silicates, or there must be a slip in your account and you have inverted the behaviour of the black and white particles.

These are the three principal points which struck me in reading your note, which is very interesting, but I must regard it as a matter of regret that the absence of specimens from the great and typical area of Berar and Malwa make the report inconclusive, as it deals exclusively with soils which have only been classed with the true cotton soil on the ground of superficial resemblance. Some of these are certainly of a different origin, and apparently quite different in their characters too, and all of them are only to be doubtfully related to the true cotton soil, from which they differ in chemical composition—very probably also in origin."

Copy of a demi-official letter No. 159, dated 21st September 1897, from Dr. J. W. Leather to R. D. Oldham, Esq., Calcutta.

"Thank you for your demi-official of 3rd instant.

Doubtless it would have been an advantage to have analysed more samples of *regur* from the Central Provinces and Berars, but still I have seen these *regur* plains, as well as those in Madras, and so far as one can judge by appearances only, there are no particular differences between them. *Regur* seems to be a soil which is so characteristically different from any other sort of soil, that even when impure, such as when it is merging into another soil on its margin, one cannot have any doubt as to whether a part is *regur* or not. But the samples which I analysed were, so far as I could judge, *pure regur*. In any case the mere variation in the relative proportions of iron and alumina can hardly affect the principal question at issue. For instance, it may be that in one large area, there is more iron than alumina, in another the reverse proportions. I do not see how it can be suggested that the *regur* in Madras is essentially different from that in the Central Provinces and

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On the Composition of

Berar or Malwa, when the principal physical features of the two are identical!

2. I notice that you still think it possible that the black colour is due to the presence of "organic salts of iron." Well, I can only point out, as I have done in my report, that in my opinion no such compounds could exist under the influences of an Indian climate. The example which you give, namely, *ink*, would become rapidly oxidised.

3. Then about the dark-coloured material which I have spoken of as a "silicate." There can be no doubt of its existence, and in another experiment which I made, I again found *white* silicates sink in a dense liquid, whilst the dark-coloured material remained floating. I was of course very much surprised at this, for I naturally expected the black stuff to be the denser.

But apart from this, the most important feature is the fact that these *regur* soils, on being boiled for some hours with concentrated sulphuric acid, remain almost entirely black, whereas all ordinary soils become white with such treatment. The black colour cannot of course be due to carbon."

19. One of the first experiments which I made with the siliceous residue of these *regur* soils, obtained, as already detailed, by the action of concentrated sulphuric acid, was to try to separate the black material from the white.

Separation
of silicates
of *Regur*.

Method.

The method by which such a separation may be effected is briefly as follows. A strong solution of some heavy metallic salt is made which has a greater specific gravity than the silicates concerned. There are several solutions which may be prepared for this purpose. The one which I employed was prepared by dissolving mercuric iodide in a solution of potassium iodide. This had a specific gravity of 2.526 at $\frac{25^{\circ}\text{C.}}{250^{\circ}\text{O.}}$. Most of the siliceous residue from *regur* floated on the surface of this liquid; that which sank was white. By cautiously adding small quantities of water, or better, of a solution of potassium iodide, the solution becomes less dense, and when a certain point is reached, the densest (specifically heaviest) matter, which had been floating, sinks. I naturally expected that the *black* material would prove denser than the white, and I was much surprised to find that the reverse is the case.

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My Experiments.

Several experiments have been carried out with the mixed siliceous matter of a number of these *regur* soils, and the result has proved to be uniformly the same. In every case the densest material was white and this sank first.

By carrying out the method of separation in careful steps, the siliceous matters were separated into half a dozen portions, all of which had decreasing densities. In the two quantitative separations which are detailed below, the first fraction was nearly white, the second grey, the third, fourth and fifth nearly quite black, and then curiously the last or lightest portion was lighter coloured.

The weights of the materials thus obtained were as follows:—

First experiment.—From 2,200 grammes of the silicates, .558 grammes (white); .030 (nearly white); .389 (dark coloured); .616 (very dark coloured); .085 (somewhat lighter coloured); .522 (grey) were obtained.

Second experiment.—From 25.897 grammes of silicates the following fractions were obtained; 3.452 (white); 2.182 (nearly white); 1.333 (grey); 1.656 (nearly black); 6.765 (blackest); 5.425 (dark grey); 5.084 grammes (light grey).

The black material was now subjected to the following further tests:—

- (a) Under the microscope it proved to be by no means all black, but the particles consisted of apparently silicate with a red and a black substance fused to them. The quantity of black particles was not by any means so large as one would have expected from the colour of the substance as a whole. But as is well known, it does not require a very large proportion of a black material, when mixed with a white one, to render the whole quite black to the naked eye.
- (b) On igniting the black siliceous material it became red. Under the microscope it was observable that the black particles had disappeared.
- (c) On treating the black material with concentrated hydrochloric acid at 100° C. for an hour or so, a certain amount of iron is dissolved, but the colour of the whole remains unchanged. Under the microscope it appeared that the black particles remained, but the red particles had diminished greatly.

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<p>Black particles possibly graphite.</p>	<p>(d) If the black material be first ignited and then treated with concentrated hydrochloric acid at 100° C., practically just the same amount of iron becomes dissolved as was the case with the unburnt black siliceous matter, but whilst the latter remained black, this burnt material became quite white. Under the microscope no red or black particles could now be seen.</p> <p>There can be little doubt that the black particles are either volatile or oxidisable, but it is doubtful whether they contain any iron at all. The iron which the black siliceous matter gives up on treatment with hydrochloric acid, both before and after ignition, is doubtless also an adhering constituent of it. I have not had an opportunity of carrying the investigation any further. It is possible that the black particles consist of graphite, fused on to the silicates, but this will require to be proved.</p> <p>These experiments had not been completed when Mr. Oldham saw my manuscript, and they will explain probably that it is quite possible for the dark-coloured siliceous matter to have a less density than the white. At any rate, there is not the least doubt that the black particles are in part composed of silica, and also that they have a less density than the white. Otherwise the latter could not have sunk first in the separating fluid.</p>
<p>Descriptions of samples.</p>	<p style="text-align: center;">OTHER "BLACK" SOILS.</p> <p>20. Among the samples of soil which I have received from Madras are three or four which are either described as "Black Loams" or have a similarity in colour to the <i>regur</i>, but which are certainly not <i>pure regur</i>. They vary much in composition and appearance. The analyses are set out in Statement No. IV.</p> <p>No. 79-96 is described as "<i>regur</i> loam ; locally known as <i>Pati-mannu</i> which is specially preferred for the cultivation of tobacco and chillies. It is from this sort of soil that saltpetre is manufactured."</p> <p>Regarding this remark, I must say that the sample contained no trace of nitrates, and, as will be evident from the analysis, there was very little nitrogen in it at all. It is a very dark-coloured sandy soil containing about 1 per cent. of calcium carbonate, much less iron and alumina and magnesia than <i>regur</i>; the amount lost on S. 2260 a.</p>

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heating is also very small, and indeed is a very poor soil in every respect excepting in that of phosphoric acid, of which the proportion is high.

It is not particularly surprising that no nitrates were present, because I imagine that the remark applies not so much to the particular land from which the specimen was selected, as to the fact that nitrates are found in similar soil *in another situation*. But it is somewhat surprising that it should be described as a good soil for the cultivation of chillies and tobacco, since land which is retained for the growth of these crops is usually kept in good "heart" by liberal allowances of manure. The assessment is entered as R1-0-0 which is low, and one must assume that *this particular field* is not utilised for the purpose in question, but rather that similar land of other fields are kept for it.

No. 328-96 is described as "black loam (called *Ilakkali pottal*); it conserves moisture very well. The soil was whitish on the surface. Cotton thrives on it." It is a grey sandy soil containing very little organic matter and nitrogen and phosphoric acid, and one would not have expected it to "conserve moisture well."

No. 251-96 is described as a "red loam; hard and saline and grey coloured; requires light and frequent showers; called locally *Tella kattu nela*." The term "red" is doubtless a clerical error. It is a grey soil full of fine *kankar* and pieces of rock, but having also something of the appearance of *regur*. Indeed the analysis indicates this, the silicates are low, the iron and alumina high—the proportion of carbonate of lime high (the carbonic acid is equivalent to 6.90 per cent.), the high magnesia, with alkalis and phosphoric acid, loss on heating and nitrogen, all in similar proportion to that in *regur*, in short a composition which could not by itself be distinguished from a good *regur*. It is probable that this is a true *regur* containing enough *kankar* and coarse rock to give it the texture of a loam rather than a good "black cotton soil."

No. 75-96 described as "*regur* clay, locally known as *Yerra masaka*." The soil had a dark brown colour and differed somewhat in appearance from true *regur*, though doubtless there was some *regur* in it. It has nevertheless a general composition similar to *regur*, and a very fair proportion of phosphoric acid.

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STATEMENT No. IV.

Analyses of Black Loamy Soils.

	KISTNA DISTRICT.	MADURA DISTRICT.	KARNOL DISTRICT.	KISTNA DISTRICT.
	Vinu Konda Taluk.	Teramanylam Taluk.	Patti Konda Taluk.	Guntur Taluk.
	79-96.	328-96.	251-96.	75-96.
Insoluble silicates and sand	90.70	82.11	59.45	73.83
Iron (Fe ₂ O ₃)	2.53	5.70	9.08	9.09
Alumina (Al ₂ O ₃)	2.18	5.19	11.86	6.60
Manganese (Mn O)	.06	.12	.12	.14
Lime (Ca O)	1.13	1.10	4.41	.88
Magnesia (Mg O)	.65	1.27	3.18	1.53
Potash (K ₂ O)	.37	.24	.56	.20
Soda (Na ₂ O)	.06	.86	.05	.17
Phosphoric acid (P ₂ O ₅)	.32	.06	.06	Nil.
Sulphuric acid (S O ₃)	Nil.	.15	.06	.14
Carbonic acid (C O ₂)	.45	.93	3.04	7.42
Organic matter and combined water (difference)	1.55	2.27	8.19	
TOTAL	100.00	100.00	100.00	100.00
Nitrogen	.006	.008	.036	.047

THE RED SOILS OF MADRAS.

21. Several samples of soil of a distinctly red colour have been sent from Madras, and their composition is exhibited in the accompanying Statement No. V.

In the "*Geology of India*," (2nd Edition), page 410, the red soils of India are thus referred to:—"The somewhat ferruginous soils common on the surface of many Indian rocks, and especially of the metamorphic formations, would probably never have attracted much attention, but for the contrast they present in appearance to the black soil. They have only been noticed as a rule in papers relating to the black soil country in the Western and Southern portions of the Peninsula. The commonest form of red soil is a sandy clay, coloured by iron peroxide, and either derived from the rock *in situ* or from the same products of decomposition washed to a lower elevation by rain. The term is, however, used in a very vague sense, apparently to distinguish such soils as are not black, and hence many alluvial soils may be comprehended under the general term. In very many cases, too, it appears to have been applied in Southern India to thick alluvial beds of sand or sandy clays, which are in fact ordinary river or rain wash deposits." Doubtless these remarks had no reference to *laterite* soils, which are not only frequently red, but also of peculiar appearance. But in addition there are also unquestionably soils of such a bright red colour that they could not for a moment be confused with any alluvium. The first six soils in the Statement are of this colour.

Bright red
colour.

No. 291-94 was a brick-red gravelly soil with the rock very near the surface:

Descriptions
of Samples.

No. 327-96 is described as a "Red loam ; red sandy soil. The plant called in Tamil *Melagapundu*, resembling chillies, is a common weed on this soil. It is said to be intoxicating to cattle."

No. 250-96 is described as "Red sand, called locally *Ferra nela* ; needs frequent and copious rainfall for the successful cultivation of crops."

No. 333-96 "Red sand ; wild indigo grows luxuriantly on the soil. The soil is not far from a hill."

No. 378-96. "Red sand ; overlies a bed of gravel at a depth of 2 to 3 feet ; is poor ; called in Tamil *pottal* ; *Cholum* and *Samai*

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SOILS.	On the Composition of
General Composition.	<p>(<i>Panicum miliare</i>) are the chief crops; natural herbage scanty; becomes somewhat hard and compact in dry weather, unlike most sandy soils, and in that condition emits a peculiar hollow sound when dug with the <i>mamooty</i>. This soil is infested with white-ants, every stalk of the stubble of the last <i>cholum</i> crop being covered with ant-hills."</p>
	<p>No. 379-96 "Red sand, similar to No. 378, but does not become so hard when dry, nor is it so infested with white-ants, natural herbage good. Considered fit for ground-nuts. <i>Ragi</i> does not thrive on this soil.</p>
	<p>It will be observed that five of these soils contain higher proportions of iron and alumina than is common to "sandy" soils. The amount of organic matter and nitrogen is also very small, the lime is only very moderate in amount, and the phosphoric acid is distinctly low.</p>
	<p>No. 74-96 is described as a "Red loam, locally called <i>Garuva</i>. Average depth of soil is 2 feet."</p> <p>Although this soil contains about as much iron as some of the others of this class, the proportion of alumina is very small. Generally regarding these soils it will be seen that the amount of lime is small or only moderate, the magnesia is not high and the phosphoric acid is uniformly low. On the other hand, the proportion of ferric oxide and alumina is usually high. Indeed their composition is in many respects very similar to the laterite soils (para. 22), the chief feature of dissimilarity being in the respective proportions of phosphoric acid. Whilst the laterite soils contained very varying amounts of this valuable plant food, its proportion in these red soils was very uniform, the extreme variation being between .05 and .09 per cent.</p>

Composition of Red Soils from Madras Presidency.

Ledger.

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DISTRICT.	COIMBATORE.	MADURA.	KURNOOL.	TRICHINOPOLY.		KISTNA.
				Parambalur.	Trichinopoly.	
Taluk.	Coimbatore.	Dindigal.	Pati Konda.			Guntur.
	291-94.	327-96.	250-96.	333-96.	378-96.	74-96.
Insoluble silicates and sand	80.33	90.47	68.10	86.74	88.84	89.31
Iron (Fe ₂ O ₃)	5.18	3.51	6.32	5.70	4.55	5.90
Alumina (Al ₂ O ₃)	7.50	2.92	15.84	5.68	3.46	1.57
Manganese (MnO)	.10	.08	.07	.10	.06	.08
Lime (Ca O)	1.11	.56	.79	.48	.10	.46
Magnesia (MgO)	.65	.70	.80	.70	.38	.30
Potash (K ₂ O)	.36	.24	.23	.05	.28	.45
Soda (Na ₂ O)	.09	.12	.19	.15	.11	.08
Phosphoric acid (P ₂ O ₅)	Nil.	.09	.06	.05	.04	Nil.
Sulphuric acid (S O ₃)	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.
Carbonic acid (CO ₂)	.85	.30	.20	.11	.03	.10
Organic matter and combined water (difference)	3.83	1.01	7.40	.24	2.26	1.75
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00
Nitrogen	.021	.006	.051	.021	.001	.012

Indian Soils.

(J. W. Leather.)

SOILS.

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SOILS.	On the Composition of
Origin of laterite uncertain.	<p style="text-align: center;">LATERITE SOILS.</p> <p>22. In the accompanying Statement No. VI. are set out the analyses of a number of soils which have been named as "laterite" by the senders.</p> <p>When summing up the evidence as to the origin of laterite Mr. Oldham (<i>Geology of India</i>, page 385) writes: "From what has gone before it will be seen that the subject of the origin of laterite is still wrapt in obscurity. None of the various hypotheses that have been propounded is completely satisfactory, nor is it possible to come to any final conclusion till an agreement is come to as to the meaning of the word laterite."</p> <p>If then it is difficult for the Geologist to decide what is "laterite," it becomes practically impossible for the agriculturist to say what is a "laterite soil."</p> <p>Those "laterite soils," that is, soil lying on or adjacent to what had every appearance of being laterite rock, which I have seen, had all a bright red appearance when dry; but as will be seen when discussing the analyses of the samples which I have examined, some at least of these are probably not true laterite.</p>
	<p>23. The following are the descriptions of the soils:—</p> <p>No. 218-96 is the surface soil of a field at Saidapet, Madras. The soil consisted of a coarse brick-red gravel. It will be observed that that there is practically no lime, no phosphoric acid, and a very small proportion of nitrogen.</p> <p>Nos. 280-96 to 283-96.—These four samples, two of surface and two of sub-soil were sent by the Deputy Commissioner of Hazaribagh. When sending them he wrote: "I have the honour to submit two samples of laterite soil, or the nearest approach to it, since laterite soil cannot be found in this district."</p> <p>All the samples were, however, of a bright red soil. They contain comparatively much manganese, and more lime than any of the other laterite soils examined, though for agricultural soils they are not by any means too well off in this particular. The amount of phosphoric acid is very low, being less than $\frac{1}{100}$ per cent. in three of them. The proportion of nitrogen, though higher than in some of the other laterite soils, is, nevertheless, low from the agricultural point of view.</p> <p>S. 2260 a.</p>

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Nos. 284 and 285-96.—These two, a surface and a sub-soil, were received from the Deputy Commissioner of Lohardaga and were selected by the District Engineer, who wrote: "The accompanying specimens, I believe, are of the laterite soil of this district or a fair representative of it. As far as I have seen, the soil is not a compact mass, but loose and gravelly, that is a mixture of pebbles of various sizes and dust; sometimes there are compact blocks mixed with the gravel; a specimen of a block is herewith submitted. As a rule these pebbles appear to be partially fused and at places there are fragments of quartz and (rarely) other rocks mixed with them. Three specimens are sent herewith.—1st, surface soil taken within 12 inches depth (No. 284-96); 2nd, sub-soil 12 to 24 inches in depth (No. 285-96); 3rd, a compact block found mixed with the loose soil (not analysed)."

The reference to the pebbles appearing partially fused is an indication that this is a true laterite gravel, the "fused" appearance being due to a crust of limonite in them. The analyses indicate that both the surface and sub-soil are so rich in iron that they might with more propriety almost be called iron ores.

The amount of alumina, though higher than in the alluvial soils of India, is not more than in the other *laterite* soils here referred to.

The proportions of lime and magnesia are low; so also is the nitrogen. The loss on heating is naturally high, owing to the high proportion of hydrated peroxide of iron. The phosphoric acid is quite unusually high in comparison with other Indian soils.

No. 358-96 is a surface soil sent by the Deputy Commissioner of Singbhum and described as laterite. It also contained a very high proportion of iron and is doubtless of lateritic origin. The sub-soil which was pink, had the general appearance of laterite. This soil also contains very little lime and magnesia, and the amount of phosphoric acid is as small as in many other Indian soils.

Nos. 360-96 to 367-96 were eight samples of soil, four surface and four sub-soil, sent by the Deputy Commissioner of Manbhum District, Chota Nagpur. Only the surface soils were analysed.

Nos. 360 and 361 are described as "*Purulia*" *tand* (high land), the former being the surface 8 inches, the latter the sub-soil. It is of a "sandy and gravelly nature." The surface soil, analysis of which is given, consisted of a soft *drab* soil, more like alluvium than anything

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On the Composition of

else; the "sub-soil" simply consisted of pieces of quartz with ferruginous veins here and there, and had no similarity to the laterite which I have seen at Madras and the Deccan. The composition of the surface soil is merely such as one would expect any alluvium to have and is devoid of striking peculiarities.

Nos. 362 and 363 are the surface 9 inches, and sub-soil of what is described as *Bengabara tand* (high land). "The land is of a sandy and gravelly nature." The surface soil 9 inches, No. 362, was similar in appearance and colour to No. 360. Its composition is similar to No. 360 in most respects, but the proportion of phosphoric acid is higher and it contains more nitrogen. The sub-soil (not analysed) was a grey lumpy earth with some little pieces of rock intermixed.

Nos. 364 and 365 are described as "*Simalia tand* (high land)." "The land is a sandy and gravelly high land almost free from grass and other weeds" No. 364, the surface 9 inches, was a brown soil; the sub-soil No. 365 was apparently laterite rock.

Nos. 366 and 367 are the surface 12" and the sub-soil of what is described as *Raghunathpur* (high land) "a mixture of mud, sand and gravel." The surface soil was similar to No. 364 in appearance, and the sub-soil consisted of laterite rock.

These four surface soils are in most respects similar to one another in composition, and excepting that Nos. 360 and 362 were more of a drab colour, whilst 364 and 366 were of a deeper brown, they were similar in appearance.

There is, moreover, nothing in their appearance or composition which is similar to the other "laterite" soils here described, and had it not been for the fact that laterite rock underlies two of them near the surface I should have assumed that they had no connection with laterite at all. Under the circumstances all that one can do is to point out the dissimilarity.

The other eight samples are probably true representatives of the laterite soils, and the somewhat wide variations in their composition, especially in the proportion of iron, illustrates a feature that one might have predicted, for a rock which itself contains hydrated peroxide of iron (if indeed it does not actually owe its origin to the presence or formation of this substance) might naturally be expected to lose larger or smaller amounts of it during its decay, the less soluble silicates being left behind. As will be

General
composition.

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seen, the amount of ferric oxide varies from 4 up to as much as 48 per cent. The amount of manganese appears to be sometimes higher than in soils generally; lime is in no case abundant, and generally it is deficient. The amount of phosphoric acid varies greatly. In two of the eight samples it is unusually high for Indian soils, but in four it is *very* deficient, and in the others the amount is lower than one might wish. Lastly, there is in no sample any large amount of organic matter or nitrogen, though in some of the samples the latter is present to the same extent as it is in *regur*.

SOILS.

On the Composition of

STATEMENT No. VI.
Analyses of Laterite Soils.

	SAIDA- PET, MAD- RAS.		HAZARIBAGH DISTRICT, BENGAL.		HAZARIBAGH DISTRICT, BENGAL.		LOHARDAGA DISTRICT, BENGAL.		SINGHBHUM DISTRICT, CHOTA NAGPUR.	MANBHUM DISTRICT, CHOTA NAGPUR.			
	Surface soil.	Sub- soil.	Surface soil.	Sub- soil.	Surface soil.	Sub- soil.	Surface soil.	Sub- soil.	Surface soil.	Surface soil.	Surface soil.	Surface soil.	Surface sol.
	218-96.	280-96.	281-96.	282-96.	283-96.	284-96.	285-96.	358-96.	360-96.	362-96.	364-96.	366-96.	
Insoluble silicates and sand	76.86	78.62	74.84	80.46	76.96	29.67	33.66	59.06	90.07	85.50	90.29	90.34	
Iron (Fe ₂ O ₃)	10.09	6.35	6.96	6.12	6.40	48.71	42.08	26.64	4.27	5.68	2.90	3.17	
Alumina (Al ₂ O ₃)	18.84	8.98	11.57	7.19	11.31	8.81	13.89	7.27	2.59	4.00	4.49	2.95	
Manganese (MnO)	.19	.39	.28	.50	.33	.07	.06	.48	.09	.11	.09	.06	
Lime (CaO)	Trace	1.50	.96	1.72	.94	.38	.45	.28	.14	.47	.14	.38	
Magnesia (MgO)	.77	.66	.81	.38	.51	.21	.20	.33	.31	.60	.28	.36	
Potash (K ₂ O)	.09	.43	.70	.38	.44	.10	.27	.27	.14	.40	.19	.25	
Soda (Na ₂ O)	.17	.21	Trace	.32	.04	.64	.26	.08	.13	.30	.04	.06	
Phosphoric acid (P ₂ O ₅)	Trace	Trace	Trace	Trace	Trace	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	
Sulphuric acid (SO ₃)	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	.12	.16	.28	.06	.05	.38	
Carbonic acid (CO ₂)	.12	.12	.08	.12	.05	.06	.12						
Organic matter and combined water (difference)	2.87	2.74	3.80	2.81	3.02	11.31	9.01	5.43	1.98	2.88	1.53	2.05	
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	
Nitrogen	.015	.039	.032	.030	.026	.010	.010	.024	.016	.032	.031	.036	

Indian Soils. (F. W. Leather.)	SOILS.
<p style="text-align: center;">COFFEE SOILS.</p> <p>24. The accompanying Statement No. VII. exhibits the composition of some soils from a coffee estate in the Sheveroys, Madras, which Mr. C. G. Lechler very kindly sent me from his Brooklyn Estate. It will be observed that one is of newly broken up jungle land, one from land which had borne coffee for two years, two of land which had been under coffee for twelve years, and two which had borne the crop for forty years.</p> <p>In physical appearance these soils were all similar, consisting of a nice open soil with a good admixture of organic matter. And, as might be expected, they are, in general composition, alike. The amount of iron and alumina, especially the latter, is unusually high (they are in no sense clays), the amount of lime very low, alkalis only in moderate amount.</p> <p>In the matter of the important plant foods, organic matter and nitrogen, and phosphoric acid they are well supplied. Moreover, comparing the soils, which had been many years under coffee, with the newly broken jungle land, it will be seen that the soil has not suffered any very serious loss by the process. They all contain somewhat less phosphoric acid and a little less nitrogen (in two cases a good deal less) than the newly broken up jungle, but excepting in the case of No. 372, which contained only .05 per cent. phosphoric acid, the differences are not great, especially when it is remembered that the samples are not from one small area, but from different parts of the estate, and one cannot of course assume that the land was in each case precisely like No. 371. Doubtless the fertility of the land has been maintained by the careful and constant manuring which the coffee planters provide.</p>	
	Source.
	Appearance.
	Composition.

SOILS.

On the Composition of

STATEMENT No. VII.

Analyses of coffee soils from Yarcand—Sheveroy Hills—Madras Presidency.

	Jungle land cleared this year.	Two years under coffee.	12 years under coffee.	12 years under coffee.	40 years under coffee.	40 years under coffee.
	371-94.	369-94.	367-94.	368-94.	370-94.	372-94.
Insoluble silicates and sand	56.31	57.88	52.61	56.84	59.72	58.31
Iron (Fe_2O_3)	11.92	9.08	10.10	10.60	9.13	9.77
Alumina (Al_2O_3)	17.31	19.74	19.94	18.62	17.88	18.34
Manganese (MnO)	.09	.06	.07	.07	.07	.09
Lime (CaO)	.32	.30	.35	.34	.31	.44
Magnesia (MgO)	.53	.38	.53	.51	.56	.66
Potash (K_2O)	.20	.14	.15	.21	.31	.29
Soda (Na_2O)	.08	.02	.07	.06	.13	.03
Phosphoric acid (P_2O_5)	.20	.10	.14	.12	Nil.	.05
Sulphuric acid (SO_3)	Nil.	Nil.	Nil.	.05	Nil.	Nil.
Carbonic acid (CO_2)	.10	.02	.10	.09	.03	.03
Organic matter and combined water (difference)	12.94	12.28	15.94	12.49	11.86	11.99
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00
Nitrogen	.170	.043	.158	.150	.065	.154

Indian Soils. (J. W. Leather.)	SOILS.
<p style="text-align: center;">TEA GARDEN SOILS.</p> <p>25. A note on Indian soils would not be complete without a somewhat detailed reference to the composition and characters of the soils of the tea districts which were examined some few years ago by Mr. H. K. Bamber, F.C.S., when Chemist to the Indian Tea Association, Calcutta, and whose book <i>On the Chemistry and Agriculture of Tea</i> was published in 1893.</p> <p>From the chapter on soils I have extracted the information contained in the following paragraphs.</p> <p>From the Dooars Mr. Bamber analysed four soils, in three of which the sub-soil was also examined, and the Statement No. VIII. exhibits their composition. The following are brief descriptions of them.</p> <p>No. 1 was a soil of the Dam Dim district, and was planted with tea in 1890 (apparently just before the analysis was made). "It was a reddish sandy loam, in a fine state of division containing much potash, mica-and occasional fragments of granitic and slaty rocks. The land was naturally well drained and the young plants were healthy and strong. The soil before being opened carried good timber forest."</p> <p>No. 2 was "a soil from the same district, but had been under tea for some years, greyish colour, very finely divided and full of mica. The bushes were fairly healthy, but had fallen off in yield, partly owing to age, and partly to the readily available plant food having been largely used up."</p> <p>No. 3 "A soil from another district in the Dooars. This was very light and friable consisting chiefly of quartz and micaceous sand, and had little retentive power for moisture. The sub-soil was similar in character to the soil, but rather more stony and open. It was found that tea plants in this soil died out in the dry season, and even when planted in the rains only produced a small sickly growth."</p> <p>No. 4. "A soil from the Dooars, on which tea would not grow during the wet season. It was of a light grey colour, in a very fine state of division, had a soapy touch, and when moistened with water, set almost like a cement. The iron was present almost entirely as the lower poisonous oxide, and this together with the large amount of impalpable matter and silicate of magnesia, which, when wet</p> <p style="text-align: right;">S. 2260 a.</p>	
	<p>Source of information,</p> <p>Dooar soils.</p>

SOILS.

On the Composition of

STATEMENT NO. VIII.

Composition of Four Soils from the Dooars.

(1)		(2)		(3)		(4)
Dam Dim District. Forest land newly planted with Tea. Reddish sandy loam. Young tea vigorous.		Dam Dim District. Similar to No. 1, but had born tea for some years and the yield had fallen off.		Dooars a light sandy soil full of quartz and micaceous and Tea died out in hot weather owing to lack of moisture.		Dooars. A very fine soil, which when moistened with water, set like cement. Tea failed during the rains.
Surface soil 18"	Sub-soil 3ft.	Surface soil 18"	Sub-soil 3ft.	Surface.	Sub-soil.	
5'95	4'44	7'27	5'39	8'19	6'17	Moisture . . . 5'000
78'35	80'73	77'55	79'64	80'19	83'27	Organic matter and combined water. . . 2'735
1'04	60	...	...	...	...	Sand and silicates . . . 79'616
07	16	17	15	06	06	Carbonate of lime . . . 2'683
1'02	30	1'91	71	54	41	Potash . . . 1'330
...	40	1'26	2'17	trace.	trace.	Magnesia . . . 1'800
7'27	9'04	12'16	}	}	}	Iron and alumina . . . 6'043
6'52	4'26	09				Phosphoric Acid . . . 1'170
09	07	09	05	10	05	Soda, etc. . . 623
100'31	100'00	100'41	99'92	100'00	100'00	100'00
344	19	365	134	...	10	
004	0003	trace.	trace.	...	...
Organic matter and combined water.		Sand and silicates		Soluble silica		
Lime (Ca O)		Potash (K ₂ O)		Manganese		
Alumina		Oxide of iron (FeO)		Phosphoric acid (P ₂ O ₅)		
TOTAL		Containing Nitrogen equal to ammonia.		Containing Nitrogen equal to Nitric acid.		

S. 2260 a.

Indian Soils. (J. W. Leather.)	SOILS.
<p>would choke the rootlets and prevent the absorption of plant food and was the probable cause of the tea bushes dying out as soon as the rainy season commenced."</p> <p>26. A class of soils called <i>bhil</i> appears to be more or less commonly met with in Assam and Cachar. The corresponding English term would be "Peaty" soils and the unbroken <i>bhil</i> soils, Nos. 5 and 15, as exemplified by the analyses quoted in the accompanying Statement No. IX. contain large proportions of organic matter and were very acid.</p> <p>The following descriptions of the soils referred to are taken from Mr. Bamber's book.</p> <p>No. 5. "A rich <i>bhil</i> soil from Assam (Nowgong district) which was very favourable for the growth of tea. It had highly retentive properties, both for moisture and manurial matter, owing to the large amount of organic humus substances and alumina contained in it. It contained only a trace of lime, however, and apparently would be benefited by an application of that constituent, as a certain quantity is removed annually by the leaf. To prevent hastening the destruction of the organic matter, the lime in this case, would be best applied as carbonate, as the soil had only a very slight acid reaction when moistened, from the organic salts present."</p> <p>No. 6. "A soil from the same district as the above which had grown tea for years and was still yielding well."</p> <p>No. 7. "Another soil from the same district under young tea yielding a large outturn."</p> <p>No. 11. "This was a heavy clay loam of average fertility that had been under tea for several years."</p>	<p>Bhil Soils.</p>

SOILS.

On the Composition of

STATEMENT NO. IX.
Composition of Samples of Bhil Soils (Assam).

	(5)	(6)	(7)	(11)	(13)	(15)	(16)	(17)	(18)
	Nowgong. Rich Bheel soil, good for tea.	Nowgong. Had been under tea for some years.	Nowgong. Young tea doing well.	Haila Kandy Dis- trict, Cachar. Heavy clay loam of average ferti- lity.	North Cachar. Low Bheel land. Blue clay.	Central Cachar. Newly opened. Bheel soil.	Under tea five years.	Under tea six years.	Under tea six years.
Organic matter and combined water.	14.74	4.30	4.70	2.13	3.90	34.29	4.21	10.81	15.40
Sand and silicates	70.10	85.47	86.49	78.37	84.75	53.04	89.61	79.73	74.37
Soluble silica . . . . .	.94	trace	trace	...	.17	.03	.01	.09	.03
Lime	trace	trace	trace	.14	trace	.07	trace	trace	.03
Potash . . . . .	.81	.41	.30	1.85	.31	.56	.27	.39	.39
Magnesia . . . . .	.24	.50	.50	.90	1.08	.37	.11	.08	.27
Manganese	1.82	.58	.75	.21	...	...	...	...	...
Alumina	9.28	5.12	1.03	9.16	3.56	10.31	...	8.44	8.40
Oxide of Iron	2.00	3.06	5.71	7.00	6.07	.83	5.08	.12	.79
Soda . . . . .	...	...	...	...	...	...	.21	.34	.32
Phosphoric acid . . . . .	...	.56	.52	.24	.16	.50	.48	...	...
TOTAL	100.03	100.00	100.00	100.00	100.00	100.00	99.98	100.00	100.00
Nitrogen equal to Ammonia . . . . .	.694	.253	.257	.22	.13	1.19	.164	.374	.578
Nitric acid . . . . .	.001	trace	.0003	...	.001	.005	...	...	...

Indian Soils

(F. W. Leather.)

SOILS.

No. 13. "A soil from the same garden (as No. 12 North Cachar) taken from low flat *bhíl* land between the *teelas*. It was a compact stiff blue clay, coloured partly with organic matter and partly with the lower oxides of iron, which required oxidation to remove their poisonous properties. Where it had been opened out and thoroughly drained, the character of the soil became changed, and tea grew on it luxuriantly; but from the pooriness of the soil in nitrogen, it would probably soon require a dressing of some manure containing that constituent, such as the various oil cakes, in order to keep up the outturn. Lime, as carbonate or sulphate (gypsum) would also be beneficial, but in the case of tea, magnesia appears to be capable of replacing lime to a certain extent, and the soil is fairly well supplied with that constituent."

No. 15. "A rich newly opened *bhíl* soil from the same estate (as No. 14 Central Cachar) nearly black in colour when wet, greyish when dry, very hygroscopic and retentive of moisture, when moistened it had an exceedingly acid reaction, which required neutralisation with lime, either in the caustic or mild state."

Nos. 16, 17, 18. "The following three analyses were made of soils taken from the same flat or lay of land as No. 15, but which had been planted out with tea in different years . . . No. 16 had been under tea about five years, and Nos. 17 and 18 six years."

27. Another description of soil which is met with in Assam is called "*Teela*." Judging by the composition of those mentioned by Mr. Bamber, they are poor sandy soils. The first two analyses in Statement No. X. are of this class. No. 12 was "a soil from North Cachar. This is a very sandy ferruginous soil, from a *teela* that had been under tea for several years, and from which the original surface soil had been largely removed by drainage. It is exceedingly poor in almost every plant constituent, and would require the frequent application of large quantities of general manures to increase the outturn of leaf. Similar soils are sometimes much improved by a heavy top dressing of *bheel* soil, rich in organic matter and nitrogen, but owing to the excessive drainage from the sharp slopes, and the small retentive power of the sandy soil for any manurial matter, most of it would be washed away from the plants before they could utilise it, and the benefit derived would be only temporary."

Teela soils.

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SOILS.	On the Composition of		
STATEMENT No. X. <i>Composition of other Tea Garden Soils.</i>			
	(12) Teela Soil from North Cachar had been under tea for several years.	(14) Teela Soil, Central Cachar, had been under tea for several years.	(19) Darjeeling, Kurseong District.
Organic matter and combined water . . .	2'66	3'78	11'28
Sand and silicates	92'17	89'63	70'33
Soluble silica	'01	'12	...
Lime	trace	'06	'25
Magnesia	'04	'23	trace
Potash	'20	'21	2'50
Soda . . . . .	...	...	...
Manganese	'06	...	'13
Oxide of Iron	2'09	3'26	5'97
Alumina	2'73	2'37	9'27
Phosphoric acid	'04	'20	'27
Sulphuric acid	trace	trace	...
TOTAL	100'00	99'86	100'00
Nitrogen equal to Ammonia	'062	'124	'535

No. 14. "A soil from Central Cachar, very finely divided ferruginous sandy soil from an old *teela* which had been under tea for several years and was similar in character to No. 12."

No. 19. "A soil from the Kurseong District, dark in colour very hygroscopic, containing much potash-mica, and fragments of easily disintegrating micaceous rock."

28. It would appear that the soils of the Tea Gardens vary very much in composition and character, as might well be expected from the fact of their position being either in the hills or in their immediate neighbourhood. The two extreme variations are represented by the *bhil* and *teela* soils. The former are, especially when first opened out, peaty, and consequently consist largely of organic debris with high proportions of nitrogen. The latter (*teelas*) are sandy. Speaking of the former Mr. Bamber says:— "Peaty soils, such as are found in Cachar and Sylhet, but more rarely in Assam, have a marvellous power of causing tea to yield rapid and heavy flushes, but such tea is not of very good quality and has little or no flavour. But after they have been opened out, drained

Description
of *Bhil* and
Teela soils.

Bhil soils.

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Indian Soils. (J. W. Leather.)	SOILS.
<p>and cultivated for two or three years, the quality of the tea gradually improves without the quantity decreasing to any extent. When first opened out, these soils are very rank and sour in character, due to the want of proper oxidation by the air, which has been prevented by the dense undergrowth of the jungle excluding the air, and to the presence of an excess of stagnant water in the soil itself. By the burning of the jungle, when cut, a large quantity of mineral matter is given to the soil in the form of carbonates, which assist in neutralising the acid humic matters contained therein, and rendering the soil fit for the growth of cultivated plants. This change is also assisted by the cutting of deep drains to remove all stagnant water containing effete and poisonous matters in solution.</p>	<p>Sour at first.</p> <p>Improvement.</p>
<p>The depth of <i>bhil</i> soils varies from 2 feet to 10 feet or more, and usually below them there is a dense sub-soil of blue clay, the colour being due partly to certain organic substances, and partly to the presence of the lower oxides of iron, which are distinctly poisonous to plants. When the soil is not very deep and the roots of the tea are likely to penetrate to a sub-soil of the above description, it would be necessary first to dig drains of some depth into the sub-soil, and so cause aëration and oxidation of the iron compounds, otherwise when the roots of the plants descended, they would absorb these poisonous constituents, which would either check their growth or kill the plants entirely.</p>	<p>Depth.</p> <p>Drainage.</p>
<p>Peaty <i>bhil</i> soils undergo a great change and loss when under cultivation, due to the combined action of the air and rain on the organic matter, which is rapidly oxidised to carbonic acid, and either washed away or given into the atmosphere as gas. Owing to this rapid and serious loss of organic matter and nitrogen, it is necessary to adopt some means of lessening it as much as possible, and this would be best done by limiting the amount of cultivation or hoeing given throughout the year. It must be remembered that these soils are already very light and porous, and when well drained admit air freely into their interior, so that cultivation is not so necessary as when the soil is more compact, and need only be done to bury the jungle when it attains a size, that would interfere with the growth of the bushes. By adopting such a system, the amount of organic</p>	<p>Changed by cultivation.</p>
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SOILS.

On the Composition of

Some *bhil*
soils are
clayey.

matter decomposed would be almost, if not quite, replaced by that obtained from the atmosphere by the buried jungle, and deterioration of the soil would be largely prevented. The well-known luxuriant growth of tea or other plants on such soils is due in a great extent to the rapid decomposition of the organic matter, which affords an abundant supply of carbonic acid for the use of the growing plant." . . . "Some *bhil* soils which have been opened out and planted with tea are very heavy in character, being composed almost entirely of a stiff blue clay, which at first has a most unpromising appearance ; however when deeply drained at close intervals and thoroughly cultivated for a year, the character of the surface soil undergoes a change in appearance and becomes more gritty and sandy, from the removal of a part of the almost impalpable matter in the soil. This alteration in character proceeds gradually deeper into the sub-soil as the drains become more active, until at last the blue colour almost entirely disappears, having changed to a pale and gradually deepening yellow.

When this change has taken place, the soil appears to grow tea luxuriantly, and such a soil will probably prove far more lasting than the peaty *bheel* soils mentioned above, owing to its retentive character for the bases liberated by cultivation and exposure of the soil to the atmosphere.

Drainage
water acid.

Value of lime.

The drainage water from most newly opened *bhils* contains much oxide of iron, which is present in the soil in the form of the lower oxide, and which is gradually deposited after exposure to the atmosphere as the higher or red oxide. It is also invariably very acid, owing to the presence of several organic acids in solution, which are very detrimental to the healthy growth of tea, and should be removed by drainage, or neutralised by lime, prior to any bushes being planted out.

If this precaution is not taken, it frequently happens that, although the plants live, their growth is checked for some months until the necessary changes have taken place, and it will be found that such plants will never flush or grow as luxuriantly as those which are planted after the soil has been sweetened by drainage and cultivation."

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Indian Soils.	(J. W. Leather.) SOILS.
<p>29. An application of <i>bhil</i> soil as manure to lighter soils, such as the <i>teelas</i>, has proved very beneficial. For instance, speaking of the soil No. 15 (<i>vide</i> Statement No. IX.), Mr. Bamber says :—" When dry this soil is richer in plant food than the cattle manure obtained in this country, and its application as a top-dressing has proved very beneficial to tea bushes on worn-out <i>teela</i> soils."</p>	<p>Value of <i>bhil</i> soils on other land.</p>
<p>30. Describing the <i>teela</i> soils, Mr. Bamber says :—" Another class of soils on which tea is largely grown, are the light <i>teela</i> soils on which tea was first planted when introduced into Cachar.</p>	<p>Teela soils.</p>
<p>Some of these soils when first cleared must have been fairly rich and strong, from the appearance of the jungle and forest growing on uncleared <i>teelas</i> at the present time, but they have in almost every case rapidly deteriorated, more from the amount removed by wash and heavy rainfall than from what has been removed by the tea itself.</p>	<p>Effect of surface wash.</p>
<p>When protected from direct rainfall by the jungle growth, they gradually increased in richness and value in the same way as other forest soils, but after the jungle was cleared away and the surface soil loosened by cultivation, they were washed down from the summit and slopes of the <i>teelas</i>, and helped to form and enrich the <i>bhil</i> soils beneath.</p>	
<p>Attempts have been made with a certain amount of success to prevent this wash by terracing the slopes of the hills, but in many cases this was only done, when the best of the soil had been washed away, and the effects were not so beneficial as they would have been had the terraces been made when the <i>teelas</i> were first cleared. The character of these <i>teela</i> soils does not vary much, being generally a light sandy loam, formed from the decomposition of the laterite rock beneath, but occasionally the soil rests upon a pebbly sub-soil, which fact, together with the sharp slopes, makes drainage too excessive, so that the bushes are very liable to suffer from drought, in any but a very wet season.</p>	<p>Terracing.</p>
<p>In a few instances the base of the <i>teelas</i> is formed of a dense whitish clay, which yield a soil very unsuitable for the successful growth of tea, but the outcrop of such a soil is usually very small in extent, and beyond its effect on the drainage of the <i>teelas</i> in which it occurs, its presence is of little importance."</p>	<p>Usually light.</p>

SOILS.

On the Composition of

Chemical
composition.

31. Regarding the composition of the tea garden soils generally, it will be observed that they are much better supplied with the plant foods, phosphoric acid and nitrogen, than are any of the other classes of Indian soils which I have examined, excepting in the case of the Coffee soils from the Sheveroy.

Nitrogen.

Phosphoric
acid.

The soils of the Dooars, as represented by the analyses quoted in Statement No. VIII., contain from '1 to '35 per cent. of nitrogen; the proportion of phosphoric acid is somewhat low in certain of them and varies from '05 to '17 per cent. But the *bheel* soils all contain much higher proportions of these plant foods. The *teela* soils seem to vary a good deal. The soil No. 12 is undoubtedly poor, but the other one of this class No. 14 contains a very ample supply of both phosphoric acid and nitrogen.

Potash.

The supply of potash in these tea garden soils appears to be ample, as indeed I have found generally in Indian soils.

Lime.

32. The particular ingredient which seems to be most deficient in the Assam soils generally is lime. Mr. Bamber remarked on this and set out in a separate statement (No. XI. of this paper) the proportions of lime found in all the soils which he examined. From this statement it will be seen how very small is the amount of lime throughout.

STATEMENT No. XI.

Proportion of Lime in Tea Garden Soils.

	Assam.	Cachar.	Kangra.	Darjeeling.	Dooars.	Chota Nagpur.
1	trace.	trace.	'38	'48	'14	'01
2	"	"	'39	'15	'30	...
3	"	"	'06	...	...	...
4	"	"	'17	...	...	...
5	"	'19	'12	...	...	...
6	'10	'11	'58	...	...	...
7	'15	'12	...	...	...	...
8	'31	'05	...	...	...	...
Average per cent. of Lime	'07	'06	'29	'32	'22	'01

In Appendix 44 of Mr. Bamber's book the cost of *burnt* lime is estimated at R112 to R128 per 100 maunds, with an additional R15 to R30 for carriage, to which has to be added the cost of the earthen jars in which it is packed. One hundred maunds per acre
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Indian Soils.

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would be equivalent to about 0·2 per cent. of lime in the first foot of soil, and this would cost about ₹150. To bring about a radical change in soils which contain so little lime, it is probable that 200 maunds would have to be applied so as to raise the percentage to about 0·5. But it is also probable that *unburnt* limestone, ground up so as to pass through $\frac{1}{4}$ inch sieve, would produce the desired effect, and the cost of this might be considerably less than the above. Another point which I do not see noticed in Mr. Bamber's book is the question whether one could not effect a remedy without the aid of lime, by burning some of the soil near gardens which require lime, or at least a free alkali. The part which the lime would play in such soils as those under notice, would be to keep the land "sweet," *i.e.*, prevent it from becoming sour. In England the process known as "pearing and burning" is employed. The surface soil is collected in heaps, mixed with fuel and burnt. The combustion is "slow" and the temperature is not allowed to rise sufficiently to burn the clay to brick, but merely high enough to liberate some of the alkalis and alkaline earths. It seems possible that this might be done in the neighbourhood of gardens, and the burnt earth applied to take the place of lime.

Cost of
liming.Pearing and
Burning.**THE POONA (MANJRI) FARM SOIL.**

33. Samples of the soil of the field at Manjri (Poona) which is devoted to sugarcane, were taken prior to the commencement of the experiments in 1894, and the proportions of nitrogen, phosphoric acid and potash determined in them. The accompanying Statement No. XII. sets out the results of those analyses.

STATEMENT NO. XII.

Analyses of Soils from Manjri, Poona.

	Plots 2 and 3.	Plots 5 and 6.	Plots 8 and 9.	Plots 13 and 14.	Plot 22.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Total Nitrogen . . .	·014	·034	·031	·024	·035
Total Phosphoric acid . .	·031	·025	·014	·022	·016
Available Phosphoric acid . .	·010	·010	·005	·008	·010
Available Potash . . .	·008	·008	·005	·009	·016

SOILS.

On the Composition of

Composition.

The proportions of nitrogen and phosphoric acid (total) are low. The amounts of available phosphoric acid and potash are probably sufficient for ordinary crops, but they are not high ; about one-third of the total phosphoric acid is readily " available."

THE NAGPUR FARM SOILS.

34. Samples from three plots at this farm were selected in 1896, and the amounts of the principal plant foods determined in them.

These are set out in Statement No. XIII.

Composition.

The proportion of nitrogen is slightly higher than that in most *regur* soils ; that of *total* phosphoric acid is about average.

The proportion of *available* phosphoric acid varies. In the surface soil of Plot A-4, which has been regularly manured, there is a very fair amount, but in the surface soil of Plots A-8 and A-7 there is very much less. Plot A-8 has been regularly manured by ploughing in a green crop, but it must be recollected that this system of manuring adds no phosphoric acid to the soil, though one might have anticipated that this procedure would have occasioned an accumulation of *available* phosphoric acid. Plot A-7 has remained unmanured, and the low proportion of *available* phosphoric acid is readily understood. The amount of *available* phosphoric acid in the sub-soil of all the plots is low.

The percentage of available potash is fair in all the samples.

STATEMENT No. XIII.

Analyses of Soil from the Nagpur Experimental Farm.

	PLOT A-4 MANURED WITH 6 TONS OF CATTLE MANURE PER ACRE PER ANNUM.		PLOT A-8 MANURED WITH GREEN HEMP PLOUGHED IN ANNUALLY.		PLOT A-7 UNMANURED.	
	Surface soil.	Sub- soil.	Surface soil.	Sub- soil.	Surface soil.	Sub- soil.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Total Nitrogen	·065	·033	·045	·033	·050	·047
Total Phosphoric acid	·093	·065	·078	·058	·064	·054
Available Phosphoric acid.	·020	·008	·008	·004	·007	·005
Available Potash	·021	·010	·016	·010	·012	·010

Indian Soils.

(J. W. Leather.)

SOILS.

THE CAWNPUR FARM SOIL.

35. A number of samples of the surface soil of certain of the experimental plots at Cawnpur have been analysed. Statement No. XIV. sets out the results.

The effect of the manures has been to materially raise the proportion of nitrogen. The proportion of phosphoric acid has not been generally increased. Of the total phosphoric acid from $\frac{1}{3}$ to $\frac{1}{2}$ is available, excepting in the case of the two plots which have been regularly manured with Indigo "Seet."

The proportion of available potash is fairly high in most cases.

Effect of
manuring.

THE DUMRAON FARM SOIL.

36. When the new land at Dumraon was taken up in 1895, samples of the surface soil and sub-soil were taken from eight spots, four in the Northern half and four in the Southern half, and the amounts of the principal plant foods determined in each.

A complete analysis of the mixed surface soil samples, and one of the mixed sub-soil samples, was also made.

The following Statement No. XV. sets out the results.

The quality of the land was remarkably uniform, and coincides generally with soils of the Gangetic alluvium. Of the total phosphoric acid, about $\frac{1}{4}$ was *available* in the surface soil, but in the sub-soil the proportion available was considerably less than this.

Land
uniform,

SOILS.

On the Composition of

STATEMENT No. XIV.

Analyses of the Soil of the Cawnpur Experimental Farm.

	Total Nitrogen.	Total Phosphoric Acid.	Available Phosphoric Acid.	Available Potash.
	Per cent.	Per cent.	Per cent.	Per cent.
<i>Unmanured Plots.</i>				
Rabi Standard No. 11	.024	.085	.021	.012
Kharif Standard No. 13	.016	.053	.022	.007
Alternate Series A No. 13	.017	.088	.030	.007
Ditto B No. 11	.023	.071	.014	.012
Green Manure Series No. 5	.017	.052	.015	.027
<i>Manured Plots.</i>				
Rabi Standard No. 3	.031	.067	.032	.012
Kharif Standard No. 3	.065	.094	.047	.027
Alternate Series A No. 6	.024	.072	.036	.012
Ditto B No. 3	.042	.072	.025	.019
Green Manure Series No. 2	.038	.089	.009	.011
(Manured annually with 120 maunds or 9,600 lbs. per acre of fresh Indigo seed.)				
Green Manure Series No. 1	.107	.079	.008	.007
(Manured annually with 120 maunds or 9,600 lbs. per acre of old Indigo seed.)				

STATEMENT NO. XV.

Analyses of the Dumraon (new) Farm.

		Indian Soils.				(F. W. Leather.)				SOILS.	
		SURFACE SOIL 1"-9".				SUB-SOIL 9"-2' 9".					
		Total Phosphoric Acid.		Available Phosphoric Acid.		Total Phosphoric Acid.		Available Phosphoric Acid.		Available Potash.	
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
North half of Farm—											
North		.043	.069	.015	.013	.043	.076	.008	.006		
South		.047	.066	.009	.009	.049	.071	.005	.010		
East		.042	.063	.012	.010	.037	.074	.005	.008		
West		.047	.099	.023	.013	.039	.084	.006	.009		
South half of Farm—											
North		.041	.081	.012	.009	.041	.065	.003	.007		
South		.043	.088	.021	.010	.039	.124	.010	.009		
East		.042	.077	.015	.012	.039	.067	.004	.007		
West.		.049	.089	.017	.015	.039	.071	.006	.010		
		Surface soil.				Sub-soil.					
Insoluble silicates and sand		86.73				80.78					
Soluble silica		.09				.12					
Iron		4.09				6.12					
Alumina		4.57				6.50					
Manganese		.10				.14					
Lime		.30				2.07					
Magnesia		.76				1.17					
Alkalis (K ₂ O Na ₂ O)		.48				.73					
Sulphuric acid (SO ₃)		...				...
Phosphoric acid (P ₂ O ₅)		.08				.08					
Carbonic acid (CO ₂)		1.07				2.29					
Organic matter and combined water		1.73				100.00					
		100.00				100.00					
Nitrogen		.049				.041					
TOTAL											

SOILS.	On the Composition of
	<p>GENERAL CONCLUSIONS REGARDING THE COMPOSITION OF INDIAN SOILS.</p> <p>37. Having now examined individually the composition of the several different classes of soil, it will be well to summarise the deductions which may be drawn from the information thus supplied and at the same time compare them with the opinion of Indian soils at which Dr. Voelcker arrived from an examination of such few analyses as were at his disposal when writing his report.</p> <p>Silicates.—The proportion of silica and silicates was determined by digesting the soil (after gentle ignition) in concentrated hydrochloric acid, and it may be here remarked that they were in all cases (even those of the <i>regur</i> soils) quite white after this treatment.</p> <p>In the soils of the great Alluvial Plains, their amount is much about the same as one is accustomed to find in English loams and clays. In the Black cotton soil (<i>regur</i>) their amount is uniformly low; due principally to the high proportions of ferric oxide and alumina and the water combined with them, and to a lesser degree to the presence of larger amounts of lime and magnesia than many English loams contain. In the Red Soils of Madras the proportion of silicates is low in two cases, due to the presence of large amounts of iron and alumina; the other samples contain high amounts. The laterite soils yielded very varying amounts of insoluble silicates, which was due almost entirely to the great variations in the amount of iron and alumina which is a chief characteristic of these soils. In the Brown Alluvial soils from Madras Presidency, the proportion of silicates is low in the loams, chiefly owing to the high proportions of iron and alumina which these soils contain. In the Coffee soils from the Sheveroys the silicates are very small in amount, due in part to high proportions of iron and alumina, but in part also to high proportions of organic matter. In the Assam soils, the proportion varies very much, according to the proportion of organic matter present.</p> <p>Iron.—The amount of Iron which exists in Indian soils appears to be in all the classes examined higher than what one is accustomed to meet with in English soils. In the soil of the Indo-Gangetic alluvium it occurs in proportions varying from 2 up to 7 per cent. In the <i>regur</i> its proportion varied from 4 up to 11.5 per cent. In the Madras red soils it varied from 3.5 to 10 per cent.; in the 8 laterite soils (the</p>
Alluvial Soils	
<i>Regur.</i>	
Red Soils.	
Laterite.	
Madras alluvium.	
Coffee Soils.	
Assam Soils.	
Iron usually high.	

Indian Soils.

(J. W. Leather.)

SOILS.

identity of which could not be doubted) from 6 up to 48 per cent., but in the four doubtful laterites it fell to a much lower figure. In six of the Madras alluviums the proportion was from 5 up to 17 per cent. In the Assam soils the proportion varied very much, but was generally high. Lastly the coffee soils contained from 9 to 12 per cent. Thus there can be little doubt that the amount of iron in Indian soils is large, in some very large indeed.

Alumina.—In the case of the alumina, too, almost all the soils examined contained high proportions. In the soils of the great alluvium, it varied from 3 up to nearly 10 per cent.; in the *regur* from 6 up to nearly 14 per cent.; in the red soils there was a good deal of variation, the extreme limits being 1·5 and 15·8 per cent.; in the first eight of the laterite soils it varied from 7 up to nearly 14 per cent., though the four doubtful laterite soils contained much less; in the Madras alluvium it varied from 6 up to 15 per cent. in the loams, but there was much less in the sandy soils. Lastly the Coffee soils contained the very high proportion of 17 to 20 per cent.

Usually high proportion.

Manganese.—This metal appears to be very widely distributed in the soils of India, though it occurs only in small amount, the proportion in the alluvial soils varied from ·11 to ·30; in the *regur* from ·1 to ·26; in the red soils from ·07 to ·20; in the laterite soils from ·06 to ·50; in the Madras alluviums from ·03 to ·26 per cent., whilst the coffee soils contained from ·07 to ·09 per cent.

Widely distributed.

Lime.—The proportion of Lime in the soils has been calculated to the oxide for the sake of uniformity. Some of the lime in all the soils exists as carbonate, some part as silicate. As is well known calcareous soils are generally absent from India, the only one of those examined that could fall under this category being the soil from Captain Chapman's estate; the peculiar circumstances under which this soil has been forming have been already alluded to. The soils of the alluvium contained from ·3 to 2 per cent.; the *regur* soils contained more, namely, from 1·0 to 7·7, the greater number of them contained from 2 to 5 per cent.; the red soils, the laterites and the Madras alluvium contained uniformly small proportions, usually less than 1 per cent., the coffee soils had about ·3 per cent., and many of the Assam soils even less than this. Dr. Voelcker writes: "speaking generally, lime is more plentifully distributed in Indian soils than

Calcareous Soils rare.

Alluvium.

Regur;

Laterite.

SOILS.

On the Composition of

Usually
sufficient.European
standard
considered in
relation to
Indian Soils.

in English ; that is, deficiencies are not so frequently met with. A notable exception, however, which I have found is in the laterite soil of parts of Southern India such as the coffee-growing districts of Coorg and Mysore, and the Tea Plantations in the Nilgiris, where, I have reason to believe, a more abundant supply of lime would be decidedly beneficial." The evidence now afforded by the analyses quoted substantiates this opinion *in the main*. There is undoubtedly sufficient lime in the *regur* soils, and most of the soils of the Gangetic alluvium contained a sufficiency; of the laterites 7 out of 12 also contained a sufficiency, and it was deficient in none of the Madras red soils. These remarks as to sufficiency and deficiency, however, are really based on a European standard, and it must be considered an open question whether it is proper to apply such a standard to Indian soils. One of the chief objects which an English farmer has in maintaining a fair proportion of lime (1 per cent. at least) in his land is the retention of a sufficient amount of free basic matter to combine with the organic acids which are constantly formed from the humus. The proportion of humus in English soils is unquestionably higher, much higher than is the case with Indian soils, and consequently it is open to doubt whether Indian soils usually are in absolute need of so large an amount of lime as one would consider necessary for English soils. Thus I feel certain that the laterite soils, for instance, which contain so little lime, would not be benefited materially by an application of it. On the other hand, the coffee soils from the Sheveroy are somewhat differently placed. The *total* amount of lime present in them is not *very* small, but still it is not large and most of this exists as silicate. These soils contain also a very considerably greater proportion of humus than other soils from the plains, and it *may* be that such land as this would be benefited by an application of lime. The Assam Tea garden soils would, I feel certain, be very greatly benefited by an application of this substance.

Generally
Plentiful.

Magnesia.—Dr. Voelcker's remark that "Magnesia appears to exist in sufficient abundance throughout, and more plentifully than in English soils" (paragraph 64) is amply confirmed. In the soils of the Gangetic alluvium it seems to be generally present in amount exceeding 1 per cent. The *regur* soils contained even more than

Indian Soils.

(J. W. Leather.)

SOILS.

this, in two samples only did the proportion fall appreciably below 2 per cent., and in one case it ran up to 3 per cent.; indeed in these soils its amount is singularly uniform, nearly all the samples containing from 2 to 2½ per cent. The red soils contained usually about ¾ per cent. There appears to be less of this element in the laterite soils than in the other classes referred to.

Potash.—The proportion of Potash appears to be ample in all classes of soils.

Ample
Potash

38. **Phosphoric acid.**—From the few analyses which Dr. Voelcker had at his disposal he concluded that phosphoric acid is “more abundantly distributed in Indian than in English soils,” and he suggests that .12 or .13 per cent. would be a good average for English soils. Of the ten analyses which Dr. Voelcker had at his disposal, five contained more than this amount and five a little less than this. The lowest was .09 per cent. Among the samples which I have examined, the majority contained considerably less than Dr. Voelcker’s standard. Of the Gangetic alluvial soils, six contained .08 or less, four contained from .09 to .13, and only two, namely, the Changa Manga soil and the calcareous one, both of which had been placed for long periods under influences of accumulation of plant food contained more than .13 per cent. Of the eighteen *regur* soils, sixteen contained .08 or less of this plant food, the other two containing about .20 per cent. Of the six red soils, four contained .08 per cent. or less, the remaining two .09 per cent. Of the laterite soils, four contained less than .01 per cent. four others .08 per cent. or less, and four others fair amounts. The Madras alluvial soils contained, as a whole, somewhat more, there being .08 per cent. or more in six out of ten samples, but the other four contained only very small amounts. The coffee soils have doubtless been well manured, and contained with one exception .1 per cent. or more. The Assam soils appear to be far better off in respect of phosphoric acid than any other soils in India. In none of those examined could there be said to be a serious deficiency.

My samples
usually con-
tained less
Phosphoric
acid than Dr.
Voelcker’s.

Thus as regards the amount of phosphoric acid, it is obvious that most of the soils of India are not abundantly supplied, but rather it must be admitted that the amount is frequently small. Glancing, too, at the analysis of the farm soils, it will be seen that the land at Manjri

Usually low
proportion.

SOILS.	On the Composition of
	<p>(Poona) contained, when first taken up for the sugar-cane experiments, '03 per cent. or less of total phosphoric acid (paragraph 32), and the soil of the (new) Dumraon Farm about '08 per cent. when first taken up (paragraph 35). On the other hand, exceptions to the general conclusion as to the usually low proportion of phosphoric acid in Indian soils, are found in the case of the Assam soils and those of the Meerut District. The soils from the Meerut District contained (<i>vide</i> paragraph 45), very distinctly larger amounts of this plant food. Some of them contained as much as ½ per cent., eighteen out of the thirty-five contained '1 per cent. or over, and only two contained less than '06 per cent.</p> <p>39. <i>Available Phosphoric acid.</i>— Although the knowledge of the total amount of phosphoric acid in a soil acts as a guide to one in forming an opinion as to the desirability or otherwise of supplying phosphates to land, still it has long been recognised that a more accurate means of judging this point would be most valuable.</p> <p>In 1894, Dr. Bernard Dyer, of London, published an important paper before the Chemical Society, in which he showed that a close relation existed between the amount of phosphoric acid which was dissolved by citric acid, and the known fertility of certain plots at the Rothamsted Experimental Station.</p> <p>An examination of a large number of the roots of plants showed that the acidity of the sap was on the average equivalent to very nearly 1 per cent. of citric acid, and Dr. Dyer then submitted certain of the Rothamsted soils to the action of a 1 per cent. solution of citric acid for seven days. He took as his standard soil, the surface soil of the field in which barley had at the time been grown continuously for 40 years. The Rothamsted experiments have yielded such uniform results that the relative agricultural fertility of the several plots was well known.</p> <p>The treatment of the soil for seven days with citric acid was admittedly empirical, but what Dr. Dyer aimed at was to demonstrate whether the result of such treatment would correspond at all with the known fertility of these standard soils.</p> <p>The result of this research showed conclusively that a very close correspondence existed between the amount of phosphate</p>
Dr. Dyer's investigations,	
Method.	
S. 2260 a.	

Indian Soils.

(J. W. Leather.)

SOILS.

thus dissolved from these soils, and their known fertility in the matter of phosphates.

A second part of the investigation consisted in answering the same question in relation to potash, and in this case likewise a close relation was made apparent between the amount of potash soluble in 1 per cent. citric acid solution, and the known requirements of the land for this plant food.

The potash and phosphoric acid in soils which is thus dissolved by citric acid is styled the "available" potash or phosphoric acid. Dr. Dyer examined twenty-two soils in this manner, and he concluded from his research that "when a soil is found to contain as little as about .01 per cent. of phosphoric acid soluble in a 1 per cent. solution of citric acid, it would be justifiable to assume that it stands in immediate need of phosphatic manure."

Meaning of
available
Phosphoric
acid.

Although for want of time, the amounts of phosphoric acid and potash rendered soluble by 1 per cent. solution of citric acid have not been determined in all the samples of soils which were considered typical of Indian agricultural land, the determination of the total and available phosphoric acid was carried out on some of the farm soils and in the case of the soils of the Meerut district. We have thus five sets of determinations of this "available" phosphoric acid, two in *regur* soil (Manjri and Nagpur), and three in the alluvium, (namely, Meerut, Cawnpur and Dumraon), and although these cannot be considered to be so fairly representative of Indian soils as those in Statements Nos. I. to XI., still it would seem that a conclusion may be drawn from them indirectly as to the amount of "available" phosphoric acid in certain classes of Indian soils.

Only certain
of my samples
tested.

The amount of total phosphoric acid has been shown to be low in most Indian soils as judged by a European standard. The further question now presents itself, "How much of the phosphates in Indian soils is available?"

Bearing in mind the standard which Dr. Dyer has proposed, namely, .01 per cent. of "available" phosphoric acid, we may glance at the analyses of the Meerut and other soils in which both the *available* and *total* phosphoric acid have been determined.

Of the thirty-five soils from the Meerut district only two fell below the standard. Of the samples from the field at Manjri (when taken up

Meerut Soils.

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SOILS.	On the Composition of
Manjri, Cawnpur.	<p>in 1894), only one contained appreciably less than '01 per cent. ; of the samples from the Cawnpur Farm, none of those from plots which had remained for 15 years without manure contained so little as the '01 per cent. limit, and most of them a good deal more ; and of the soils from the Dumraon Farm when taken up in 1895, only one contained less than the standard (namely, '009 per cent.).</p> <p>Most of the Meerut soils doubtless contain much more than an average amount of phosphoric acid, and may, for the moment, be set aside. The Manjri soils contained no large amount of total phosphoric acid (only '015 to '03), indeed very decidedly less than what <i>regur</i> soils have been shown to generally contain. The soil of the new Farm at Dumraon contained about '06 to '08 per cent. total phosphoric acid, which is much about the same as the soils of the alluvium have been shown to contain generally ; and the soils from the unmanured plots at Cawnpur, containing from '05 to '08 per cent. total phosphoric acid, have also much about an average allowance. Thus it is seen that, although the only soils in which the <i>available</i> phosphoric acid has been determined are from but a few places, the farm soils are not exceptionally rich in <i>total</i> phosphoric acid. Whilst therefore it is admitted that these are examples of soils from five particular spots, it is nevertheless evident that the percentage of total phosphoric acid in the soil of the farms is not abnormal, and that they cannot be said to be <i>exceptional</i> soils.</p> <p>A further point may now be taken into consideration, namely, " what proportion of the total phosphoric acid in these Indian soils is " available?" and is that proportion about the same or different from what Dr. Dyer found to be the case in the Rothamsted soils? Looking over Dr. Dyer's analyses, I see that of the total phosphoric acid in the soils of the <i>manured</i> plots, about $\frac{1}{4}$ or $\frac{1}{3}$ was " available," whereas in the case of the unmanured plots, only about $\frac{1}{10}$ of the total phosphoric acid was " available."</p> <p>The Indian Farm soils which have been referred to are examples of either unmanured, or at least but very <i>slightly</i> manured land, and in no case equivalent to the <i>manured</i> plots at Rothamsted, rather, on the contrary, do they more nearly approach to the unmanured plots at Rothamsted.</p>
Dumraons.	

Proportions
"available,"

Indian Soils.

(F. W. Leather.)

SOILS.

Turning now to the analyses of these soils, in those from Manjri from $\frac{1}{3}$ to $\frac{1}{2}$ of the total phosphoric acid was "available;" in the Dumraon soil about $\frac{1}{4}$ of the total phosphoric acid was "available;" in the unmanured Cawnpur Farm soils, from $\frac{1}{4}$ to $\frac{1}{3}$ of the total phosphoric acid was available; in those of the Meerut soils, which contained large amounts of phosphoric acid, the proportion is very much higher; in those containing less phosphoric acid, the proportion varies generally from about $\frac{1}{5}$ to $\frac{1}{3}$. In the unmanured land at Nagpur, only about $\frac{1}{10}$ was available, but in this case a process of exhaustion had been going on for some years. Thus it is seen that, although most of these soils (excluding the rich Meerut soils) contained rather small percentages of *total* phosphoric acid, they not only generally contain more than the standard 0.1 per cent. of "available" phosphoric acid, but also that the *relative* amount of "available" phosphoric acid is high.

Usually up to
Dr. Dyer's
standard.

It has been pointed out that the farm soils named are, in no particular exceptional, and indeed they may be considered as fair samples of the Gangetic alluvium and of the *regur*, respectively; it may then be fairly assumed that in these two great types of Indian soils about $\frac{1}{3}$ or $\frac{1}{4}$ of the total phosphoric acid is generally "available." The importance of these considerations will become the more evident if reference is now made to the analyses of the alluvial and *regur* soils in Statements Nos. I. and III.

It will then be seen that if $\frac{1}{4}$ of the total phosphoric acid be generally "available", it is only rarely that we find a soil deficient in this plant food, and thus, although the Indian soils have frequently or generally a low proportion of *total* phosphoric acid, it is likely that the proportion of *available* phosphoric acid is not usually deficient.

Probably
alluvium
and *Regur*
usually
contain
enough
"available"
Phosphoric
acid.

It would of course not be proper to assume a similar deduction for the red soils of Madras and the laterite soils, since the "available" phosphoric acid has not been determined in any soil of these two classes.

The deduction regarding the amount of *available* phosphoric acid is also quite in accord with the fact that at one farm only (namely Burdwan) have bones been found to be of any service as manure. At each of the other four farms bones have regularly been applied to certain plots in the field experiments, and in no case has it been found that a materially increased outturn results from the application.

This does not
apply to
other types.

SOILS.

On the Composition of

Little
Sulphates.

40. *Sulphuric Acid*.—Like phosphoric acid, when sulphuric acid is present in a soil, it always exists in combination with some one or other of the metallic oxides with which it forms sulphates. There is usually no simple means of determining with which base it is associated, and for purposes of ready expression, its amount is calculated in the form of the anhydride. The majority of Indian soils (excluding of course those which are impregnated with soda salts) contain remarkably little sulphate, and its amount was in no case as much as 1 per cent.

Carbonic Acid.—This was determined in order to see to what extent the lime exists as carbonate. This constituent need hardly be referred to here; it has already been pointed out that its amount is usually less than sufficient to combine with the lime, and that consequently it may be assumed to be in combination principally with that oxide.

Meaning of
this term.

41. *The Organic Matter and Combined Water*.—The figure indicating the amount of these two items in the statements are in all cases the difference between the sum of the other ingredients and 100 per cent. The loss which the soils experienced on heating was determined in all cases, and differed but little from the figures quoted. Although certain deductions in some cases can be made regarding the relative proportions of the true organic matters or humus contained in the soils, and the amount of the water which is chemically united with them, the knowledge of the loss by combustion of a soil does not serve as a means of even approximately determining the amount of that most valuable constituent humus. It may be said, however, that in the event of any soil containing a fair proportion of organic material, the fact is readily observable to the operator who watches the appearance of the soil when placed in a receptacle over the lamp.

Referring in the first place to the amount of "organic matter and combined water" in the several classes of soils, among the alluvial soils, there are two clays which suffered a material loss, but not more than such clays would be expected to suffer, and the greater part is doubtless due to the expulsion of water; these two soils are, however, doubtless in fairly good condition and the amount of organic matter is probably higher than in most. The soil from Changa Manga and that from Captain Chapman's doubtless contained a good deal of

Indian Soils.

(J. W. Leather.)

SOILS.

accumulated humus, but as I have already explained they have been placed under quite exceptional circumstances. All the other soils of this class undoubtedly contain but small amounts of organic matters.

Usually little organic matter in alluvium.

The *regur* soils uniformly suffer a greater loss on heating than do those of the alluvium. I have already dealt with the question as to whether much of this may be attributed to organic matter or not in the para. 13, devoted to *regur*, and need only say here that the amount of humus in them is probably quite as small as the soils of the alluvium. The loss which the red soils of Madras and the laterite soils experienced, varied very much indeed, but it will have been noticed that it is high only in those cases in which the amount of iron and alumina are high; a similar remark applies to the alluvium from Madras Presidency, and taking into consideration the general appearance of these soils it may be safely said that the amount of organic matter is usually very small in them. The coffee soils from the Sheveroy Hills undoubtedly contained a high proportion of organic matter. Their appearance indicated it, the amount of nitrogen which they contain is considerably higher than in any of the other classes of soils examined, and all doubt on the point is removed by their appearance on burning. Finally, the *bhil* soils of Assam appear to contain very high proportions of organic matter, especially when first taken up. The *teela* soils of the same province contain only small proportions. Dr. Voelcker came to the conclusion that, with the exception of *regur*, Indian soils are deficient in humus, but even as regards *regur* he says "That it has peculiar powers there is no question, but that it is so rich in vegetable matter and in nitrogenous ingredients as to be independent of manure I do not think".

Probably little humus in *Regur*.

42. **Nitrogen.**—Glancing over the figures which represent the percentage of nitrogen in the various classes of soils, it will be seen that with the exception of the Assam soils, those from Partabgarh and Changa Manga and those from the Sheveroy, which cannot be considered as typical of Indian soils generally, there is in no case so large an amount of nitrogen as 0.1 per cent. Among the soils representing the Gangetic alluvium, 3 out of 10 contain .05 per cent. or a little more, the rest less; among the alluvial soils from Madras, two contained about 0.1 per cent. and two contained about .05 per cent. but in the

Usually little nitrogen

S. 2260 a.

SOILS.

On the Composition of

Dr. Voelcker's
opinion sup-
ported.

other six samples the proportion was much less. Of the 18 samples of *regur* soils, one only contained '05 per cent., the other 17 containing less; among the red soils from Madras one contained '05, the other 5 less; among the 12 laterite soils not one contained as much as '05 per cent., and most of them only about '03 per cent. or less. On the other hand the Assam soils contained uniformly high proportions of nitrogen, and those soils which have had an opportunity of accumulating nitrogen contained very fair amounts. The soil from Partabgarh contained '18, the surface soil at Changa Manga '237 and the coffee soils from the Sheveroy's '04 to '17. Thus the opinion to which Dr. Voelcker came, namely, that Indian soils are generally very deficient in nitrogen content is amply supported. Moreover, if the analyses of the other soils which are quoted in paras. 32-35 namely, the farm soils, and those from the Meerut district, be examined, the same tale is told. Among the soils from the Meerut district (para. 45) some of the clays contained more than '05, but none so much as '1 per cent., and the proportion in the more loamy soils falls considerably below '05 per cent. The soil at Manjri (Poona) when first taken up for the Sugar-cane experiments contained '035 per cent. or less (*vide* para. 33) The soil of the new Farm at Dumraon contained about '045 per cent. (para. 36).

SPECIAL CASES.

43. The following special cases relating to soils have been submitted to me:—

The first is one of some land in the Amherst District, Burma, which is thus described by the Settlement Officer.

Copy of a letter No. 93-1—26, dated 1st April 1896, from the Settlement Officer, Amherst District, Maulmein, to the Reporter on Economic Products to the Government of India.

Burmese
soil near
hot springs.

I have the honour to advise the despatch to your address on the 28th ultimo of a case containing certain specimens of soil and water connected with the cultivation of onions and tobacco, which would probably be of some interest.

In the neighbourhood of Yebu village, Gyaing Attaran township, Amherst, are some hot springs or tanks of boiling water, a description of which will be found in the *British Burma Gazetteer*, Vol. 1.

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Indian Soils.

(J. W. Leather.)

SOILS.

Description
of locality.

The springs are found in low rising ground in the middle of an inundated plain, and the soil immediately round them is laterite. In the immediate neighbourhood of these tanks from which the water bubbles off on the low ground below or is carried into the river *Attaran* by a nullah, are cocoa-nut and betel-nut plantations. The cocoa-nuts have the same flavour as those found near the salt water in the Gulf of Martaban. The soil is only about four feet in depth, and below that water is reached. I send you a specimen of sub-soil No. 3 about eight inches below the surface. On the lower ground on either side the water is too deep in the rains to work any crop, but immediately the water subsides, drains are dug round the plantations and the surface soil dug up with a *mamoti* and the earth thrown up in ridges, on which onions are planted; the crop is taken in February and then a crop of tobacco and chillies, mixed with maize and country vegetables is planted. The specimens now sent were taken in the month of March while the second crop was on the ground, and are, first, a specimen of low lying surface soil No. 1 (b) taken from Nga Kannas' field in which a crop of tobacco mixed with maize is planted after the onion crop was taken, and secondly, a specimen No. 2 of high lying hard soil taken from Nga Gunnas' field, in which chillies and country vegetables were planted after the onion crop was taken; about two feet to three feet below the soil, water is reached. The cultivators say that they cannot work the same soil more than five to six years continuously, and not as long as that. The soil gets worn and the crop is poor and will not produce without a long rest. I cannot, however, give any confirmation of this. They say that, if salt water is let into the fields again, it has no fertilising properties, and the land cannot be continuously worked by this means. I also send a specimen of the boiling water from the springs, No. 2, and of water taken from the drain leading past the cultivation No. 3. I should be glad if you could let me know the result of any analysis you make for insertion in the Settlement Report.

The onions grown are the small red onions and sell at Rs. 10 to Rs. 15 per 100 viss,* they say, and the tobacco sells at Rs. 1 per viss, local sale. The cultivation covers only a small area.

The following report which was subsequently submitted, explains the composition of the water and soils in question.

* One viss equals 3'65 lbs., Avoirdupois.

Indian Soils.

(F. W. Leather.)

SOILS.

Composition of the Soils.

	^{95.8} No. 3.	^{23.4} No. 1 (b).	^{21.5} No. 2.
Silicates and Sand	21'35	59'61	05'25
Oxide of Iron	28'11	2'08	1'49
Alumina	4'65	13'11	12'16
Oxide of Manganese	'14	—	—
Lime	18'79	'85	'87
Magnesia	3'00	'72	'63
Potash and Soda	1'06	1'51	1'27
Phosphoric Acid	1'06	'06	'05
Carbonic Acid	13'09	'62	'03
Organic Matter and Combined Water	8'75	22'04	18'25
	100'00	100'00	100'00
Nitrogen	'19	'51	'41

Regarding in the next place the soils, that which is numbered 3 contains a very exceptionally large amount of oxide of iron, also a very large amount of calcium carbonate and a very small proportion of silica. I conclude from the Settlement Officer's letter, however, that it is in regard to the composition of the other two soils, numbered 1 (b) and 2, that information is more particularly required. They are quite different from No. 3 and are of a more ordinary description. Both contain a low proportion of oxide of iron and a high proportion of alumina, with a high proportion of organic and nitrogenous matter; the amount of sand is low as also is the amount of phosphoric acid. They are, I imagine, stiff clays, and difficult to work.

No. 3
peculiar.

No. 1(b) and
2 ordinary.

SOILS.

On the Composition of

Excepting that the amount of phosphates is low, they are not (chemically) poor soils. But if, as I understand, the water from the hot springs flows over these lands, a reason is apparent why the people find a difficulty in raising crops on these soils. There is nothing more prejudicial to plant life than sulphuretted hydrogen, and if the water brings this over the land, the crops are bound to become affected.

There is, it seems to me, only one way out of the difficulty, and that is to keep this water from the springs away from the land. Whether this is possible, I cannot of course say, but if it be possible, then, I should expect the land to be improved rather than injured by cultivation. It is, however, a soil which will always require good, *i.e.*, expensive, tillage. It is one which requires as much exposure to the sun and air as one can give it.

44. Another case of infertility was referred to me by the Conservator of Forests, School Circle.

Copy of a letter No. 287, dated 5th March 1897, from the Deputy Conservator of Forests, Dehra Dun Division, to J. W. Oliver, Esq., Conservator of Forests, School Circle, North-Western Provinces and Oudh.

Dehra
soil.

I have the honour to send herewith three samples of soil for analysis by the Agricultural Chemist. They were collected by me from the top soils of three separate places in compartments 16 and 17 in the Dholkot Forests.

2. I have numbered them both inside and outside.

Sample No. 1 was collected from the top soil of an open glade surrounded by tall *sal* trees, the spot being perfectly open above and within easy reach of falling *sal* seeds.

The spot contained no young growth.

Sample No. 2 was collected from a similar spot, but the young growth was of medium quality.

Sample No. 3 was collected from under a very thick growth of young *sal* trees about 25 feet high.

3. Kindly let me know the results of the analysis.

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Indian Soils.

(J. W. Leather.)

SOILS.

As the following report shews the infertility of the land was due to natural poverty of the soil:—

Analyses of samples of Soils from the Dholkot Forests.

	⁸⁷ / ₉₇ No. 1.	⁸⁸ / ₉₇ No. 2.	⁸⁹ / ₉₇ No. 3.
Nitrogen (total.)	·043	·101	·152
Available Phosphoric Acid	·026	·028	·048
Total Phosphoric Acid	·105	·112	·144
Calcium Carbonate	·187	·293	·685

The soil No. 3 is the richest and No. 1 the poorest in plant-food, and this will probably explain why the latter does not produce so much young growth.

MEERUT SOILS.

45. In 1895 Mr. Wyer, the Collector of Meerut, sent a number of samples of soil for analysis. It was impossible to make complete analyses of so many, and therefore only the proportions of the most important ingredients were determined. The following is a copy of the report which I submitted on them, and the Settlement Officer's reply is also added.

Copy of a letter No. 426, dated 12th March 1897, from the Agricultural Chemist to the Government of India, to the Settlement Officer, Meerut.

I have now the honour to forward the results of my examination of the samples of soils which were forwarded by Mr. Wyer, on 15th April 1895. (*Vide* statement XVI.)

2. This list is arranged according to the physical characteristics of the soils, and the analyses indicate that, so far as mere chemical constituents are concerned, the clayey soils are the richest in plant-food, which is a characteristic of clay soils generally in other countries.

3. Of course any advantage which a soil may possess in respect of its richness in plant food, may be quite outbalanced by accumulations of the objectionable soda salts, known as "*kallar*" or "*reh*."

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SOILS.

On the Composition of

Meerut soil
Map.

4. I should feel much interested to know in how far the value which you have placed upon these soils agree with the chemical analyses.

5. I should have been glad to compare the analyses also with the soil map of the Meerut district, which is reproduced in the last settlement report, but the exact places from which the soils were taken has not been forwarded to me. For example, 4 samples were from Loni village, one being a grey clay, another a grey (sandy?) soil, a third yellow "burya" *usar*, and the fourth a yellow sandy soil. The village Loni apparently touches two very different tracts, and therefore I am unable to tell which of these samples belong to one tract, which to the other.

Copy of letter No. 346 A.—3-5, dated 18th June 1897, from the Settlement Officer, Meerut, to the Agricultural Chemist to the Government of India.

Settlement
values.

I have to thank you for the very interesting list of soil analyses sent with your letter No. 426, dated 12th March 1897, and regret that by an oversight it has been left so long unanswered.

2. It is rather difficult to answer your question, how far the value placed on the different soils agrees with the chemical analyses. These relative values vary from *pargana* to *pargana* and are affected by several conditions. For instance the outstanding distinction throughout the district is that between irrigated and unirrigated, the difference being often double and never less than one and-a-half; if nearly the whole area is irrigated in any particular tract, it is probable that there will be little difference in the rates paid for good and bad dry soils, the reason being, as I understand, that there are certain crops which are always grown on dry soil, and the necessity of growing these forces up the rate on bad soil almost to the level of the rate on good.

3. The difficulty of answering your question is increased by the fact that the only village on your list which I have examined in detail is Dastoi, *pargana* Sarawa. This is a fairly fertile village, certainly above the average, and I am surprised that the analysis of the soils does not show better results; perhaps they were not typical specimens. Perhaps the best way of giving you an idea of the relative values placed on the different soils is to quote the rates at which land is actually leased in the *parganas* in which I find that most attention is paid to natural
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Indian Soils.

(J. W. Leather.)

SOILS.

distinctions, Puth and Garhmuktaishur. In these *parganas* the rates are :—

Best loam, irrigated	Rs. 12	per acre.
„ dry	„ 6	„
Second class loam, wet	„ 9	„
„ „ dry	„ 6 to 4-12	per acre.
Sandy loam or superior sandy soil, wet	Rs. 6	per acre.
„ „ dry	„ 3	„ „
Inferior sandy soil, dry	„ 2 to 1-4	„ „
Clay, wet	„ 9 to 6	„ „
„ dry	„ 6	„ „

These are the rates in the best villages but the proportions are much the same, though the rates are lower in those which are inferior.

4. The case of clay may be specially noticed, as analysis shows it to be particularly rich in plant-food. Here I can say without hesitation that the relative value I have given for two *parganas* prevails throughout the district. Dry *dakar*, as it is called, pays as high a rate as the best dry soil, wet *dakar* always pays something below the rate of the best wet soil ; generally speaking about a fourth less. On the whole it is regarded as an inferior soil, and the reason no doubt is that it always lies in depressions and is liable to damage from excess of water. The reason why the dry *dakar* rate is high in proportion is no doubt that under normal circumstances it can produce valuable crops without water. The most distinctive crops grown in *dakar* are rice and gram and, although no doubt in years of deficient rain-fall the rice will fail without irrigation, yet in an ordinary year it is probable that it gets as much water as it requires. Irrigation in the case of gram is of course exceptional.

5. I have looked up the old Settlement Report, but cannot find the soil map you refer to. I do not know that it would be of much assistance. There are, of course, tracts of extraordinarily uniform soil— witness the *parganas* of Baraut, Chaprauli and Katana, or at least as much of them as is not affected by the action of water on the ravines of rivers, but as a general rule the soil varies rapidly from village to village, and it is no uncommon thing to find one village containing all gradations of soil from the most incoherent sand to the very richest loam. I do not know who selected the samples of soil, but I think the selections might have been more typical. The richest part of the district, for instance, is undoubtedly the part of Baraut, Chaprauli and Katana to which I have referred ; it has been called the richest tract in the North-West Provinces. There we have also, as I have said, a singularly uniform soil, and the analysis of a soil

SOILS.

On the Composition of

sample taken from any part of the tract might fairly have been considered applicable to a larger area than in the case of a sample taken from any other part of the district, but I see that you have not had a single example from there. The only village, in fact, of which you have a sample from the whole of that *tahsil*, is Baghpat itself, and Baghpat being a village on the ravines of the Jumna, with rapidly varying soils, is, in my opinion, a very bad village from which to select a soil specimen.

STATEMENT No. X
Composition of Meerut Soils.

Laboratory No.	Description of Soil.	Village.	Pargana.	Total Nitrogen.	Total Phosphoric Acid.	Available Phosphoric Acid.	Available Potash.
306	Grey Clay . .	Loni . .	Loni . .	·064	·484	·340	·200
328	Ditto . .	Bagpat . .	Bagpat . .	·035	·131	·024	·020
323	Ditto . .	Sarsat Dargada . .	Barnawa . .	·064	·310	·157	·061
304	Ditto . .	Jellalabad . .	Jellalabad . .	·055	·146	·066	·033
308	Ditto . .	Dhulana . .	Dasna . .	·044	·204	·123	·068
313	Ditto . .	Sapuawat . .	Ditto . .	·070	·110	·039	·027
318	Ditto . .	Shah Moha-yuddinpore . .	Hapur . .	·076	·120	·045	·019
319	Ditto . .	Dastoi . .	Sarawa . .	·035	·069	·016	·016
316	Ditto . .	Sapuawat . .	Dasna . .	·053	·501	·432	·068
310	Ditto . .	Dhulana . .	Ditto . .	·051	·536	·411	·119
303	Grey Clay (Sotha) . .	Jellalabad . .	Jellalabad . .	·091	·544	·480	·115
296	Ditto . .	Loni . .	Loni . .	·038	·421	·209	·111
301	Grey Usar . .	Jellalabad . .	Jellalabad . .	·027	·110	·041	·015
299	Ditto . .	Dhulana . .	Dasna . .	·068	·310	·230	·070
314	Yellow Usar . .	Sapuawat . .	Ditto . .	·035	·061	·010	·014
298	Ditto . .	Loni . .	Loni . .	·021	·142	·047	·028
305	Yellow red loam . .	Sharf Dim Badar Chhawani . .	Ditto . .	·032	·151	·145	·013
307	Red loam . .	Ditto . .	Ditto . .	·037	·067	·015	·010
311	Yellow loam . .	Ditto . .	Ditto . .	·038	·110	·044	·016
312	Ditto . .	Ditto . .	Ditto . .	·041	·241	·145	·035
324	Red loam . .	Bagpat . .	Bagpat . .	·041	·041	·032	·042
325	Ditto . .	Ditto . .	Ditto . .	·035	·061	·017	·007
321	Yellow loam . .	Banoli . .	Barnawa . .	·048	·068	·015	·012
327	Red loam . .	Ditto . .	Ditto . .	·034	·080	·022	·016
302	Yellow loam . .	Jellalabad . .	Jellalabad . .	·039	·096	·042	·042
315	Red loam . .	Sapuawat . .	Dasna . .	·034	·065	·011	·005
326	Grey loam . .	Meerut . .	Meerut . .	·037	·092	·055	·018
297	Red sandy . .	Sharf Din Badar Chhawani . .	Loni . .	·023	·060	·031	·008
309	Yellow sandy . .	Loni . .	Ditto . .	·029	·068	·014	·012
330	Grey sandy . .	Ranchhor . .	Barnawa . .	·034	·090	·062	·015
300	Red sandy . .	Jellalabad . .	Jellalabad . .	·034	·072	·043	·011
317	Yellow sandy . .	Shah Moha-yuddinpore . .	Hapur . .	·020	·067	·027	·002
320	Red sandy . .	Dastoi . .	Sarawa . .	·025	·047	·005	·018
329	Yellow calcareous . .	Bagpat . .	Bagpat . .	·033	·104	·016	·014
322	Ditto . .	Prichhatgarh . .	Khator . .	·046	·045	·003	·008

Indian Soils.

(J. W. Leather.)

SOILS.

THE "CHOS" LANDS OF HOSHIARPUR DISTRICT.

46. At the end of 1894 I received samples of soil from three places in what are known as the Hoshiarpur *Chos* lands. These lands are the production of excessive deposits of sand, brought down by rivers from the Himalayas, on the top of the older agricultural soil of this part of India. The investigation was undertaken with a view to determine what difference there was between the newly-deposited sand and the older soil.

The following report, which was submitted in August 1895, contains the results of the investigation, to which is added a letter from the Deputy Commissioner on the subject of how long a time is required for the newly-deposited soil to become fertile :—

Report on the composition of six samples of soils from the "Chos" lands of the Hoshiarpur District, Punjab, which were forwarded by the Deputy Commissioner in November 1894 to the Agricultural Chemist to the Government of India.

The accompanying statement (No. XVII) exhibits the results of the chemical analyses which I have made of the above-mentioned soils. I have not yet had an opportunity of personally inspecting these lands, but I understand that they are subject to periodical floodings from the hill streams, and that it frequently happens that the silt left behind by the subsiding water is of a very sandy nature, so much so that good land is frequently covered with a loose sandy soil, the latter being agriculturally inferior to the older soil.

I suggested that samples should be sent to me from different spots, of which one (in each case) should be a sample of the newly-deposited soil, or what is now the "surface" soil, the other should be a sample of the older soil, which had become covered up, and which is now the sub-soil.

Three such pairs of samples were sent to me by the Deputy Commissioner of Hoshiarpur, in November 1894, which bore the labels "Hoshiarpur," "Dosuya", and "Garshankar," respectively, but I have not been informed at what depth the "sub-soil" samples were taken. I presume, however, that these latter were not at any great depth, but are found at some 12 to 24 inches below the surface.

Considering in the first place the mechanical condition of these

Cause.

Method of
Sampling.

Sources.

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SOILS.	On the Composition of
Physical appearances.	<p>soils, the soil from Hoshiarpur and Dosuya were distinctly different from those from Garshankar.</p> <p>The soil from Hoshiarpur was a light grey coarse sand at the surface, its sub-soil being somewhat darker, much finer, but still sandy. The soil from Dosuya was a light grey coarse sand at the surface whilst its sub-soil was of a red colour, much finer, but still sandy. The surface soil from Garshankar was sandy, but reddish brown and much finer than the surface soil at Hoshiarpur and Dosuya, its sub-soil was very similar to it. Thus it seems that there is a similarity between the soils at Hoshiarpur and Dosuya which are, especially at the surface, much coarser sandy soils than that at Garshankar. In the statement of analyses, the pairs follow one another. Column 2 contains the result of analysis of the surface soil at Hoshiarpur; Column 3 those of its sub-soil; Column 4 those of surface soil from Dosuya; Column 5 those of its sub-soil; Column 6 those of surface soil from Garshankar; Column 7 those of its sub-soil.</p>
Method of comparison.	<p>In considering in what manner chemical analysis would best throw light on the respective merits of these soils, I decided to determine in each case the proportion of phosphoric acid and of potash which is readily or immediately available to plant life, and also in each case the <i>total</i> amount of phosphoric acid and of potash contained in them. I have also determined the amount of potash which is soluble in hydrochloric acid. This, like the proportion of "available" potash, indicates the relative extent to which these soils have decomposed.</p> <p>The former determinations would thus show the relative <i>present</i> value of the soils, the latter would indicate whether the newly-deposited surface soil might eventually become as good as the older soil, if it should be inferior at the present time.</p> <p>I have also determined the amount of nitrogen in these soils. There is at present no means of determining what proportion of the nitrogen in a soil is "readily available" to plants, and the figures in the statements all refer to the total amount of this constituent.</p>
Nitrogen.	<p>The further study of the figures in the statement is now simple. In the case of the nitrogen, it will be seen that in each case the surface soil contains very much less nitrogen than its sub-soil, and, moreover, that the soils at Hoshiarpur and at Dosuya contain very much less nitrogen than that at Garshankar. The proportion of</p>

Indian Soils.

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SOILS.

phosphoric acid is not quite so regular. At Hoshiarpur the surface soil contains approximately as much of this constituent, whether readily available or not, as its sub-soil. In the Dosuya samples whilst the total amount of phosphoric acid is somewhat less in the surface soil than in the sub-soil, the amount readily available is much more. In the samples from Garshankar we find considerably less phosphoric acid, both "readily available" and total in the surface than in the sub-soil. In the case of the potash, however, we meet with greater uniformity. The proportion immediately available is much less in the surface soils at Hoshiarpur and at Garshankar than their respective sub-soil; the respective proportions in the Dosuya samples are equal and at the same time very small. The proportions of potash "soluble in hydrochloric acid," which includes much more than what is immediately available to plants, are in each of the three cases much less in the surface soils than in their respective sub-soils. Lastly, the proportion of total potash, though they vary somewhat among the samples, appears to be much about the same. The sub-soil at Dosuya contains less than the others, but this may be accidental.

Phosphoric acid.

Potash.

In conclusion, it would appear generally that the surface soils are agriculturally distinctly poorer than the sub-soils, at present, but that they will eventually become as good. They are, in two cases especially, very much coarser, and this means that they would dry very rapidly indeed, for they will not prevent water from passing downwards, and it will also evaporate much more quickly from their surface. The proportion of nitrogen is as usual in Indian soils, very low indeed, but it is not lower than I should have expected.

Top soil poorer than sub-soil.

The total amount of phosphoric acid is not high, but it appears to be generally in a readily available form.

The total amount of potash lastly is distinctly high, as is also that portion of it which is soluble in hydrochloric acid. The portion immediately available is in all cases fully ample for the requirements of average crops of cereals. The most important question in relation to these soils is "at what rate do they disintegrate and decompose"; *i.e.*, how soon may these new deposits be expected to become agriculturally equal to their sub-soils? If any information can be gained on this point, it would be most valuable.

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SOILS.

On the Composition of

Copy of a letter No. 145, dated 22nd May 1896, from Captain E. Inglis, Deputy Commissioner, Hoshiarpur.

Length of time re-quired for new-soil to become food.

With reference to your office endorsement No. 2446, dated 14th September 1895, on Dr. Leather's Report on analysis of soils of Hoshiarpur Chos, I have the honour to report that a cultivated area, converted by Chos into pure sand, if properly planted with *kharkana* and manured with cow-dung, becomes fit for cultivation within 8 or 10 years, as observed in villages Naloian, Mazian and Dual. But as regards resuming its original fertility it takes much longer. This period is estimated not less than 50 years.

STATEMENT No. XVII.

Analysis of Samples of Soils from the Hoshiarpur District, Punjab.

	HOSHIARPUR.		DOSUYA.		GARSHANKAR.	
	(401) Surface soil.	(402) Sub-soil.	(403) Surface soil.	(404) Sub-soil.	(405) Surface soil.	(406). Sub-soil.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Nitrogen . . .	·0065	·015	·0065	·023	·031	·067
Equal to Ammonia	·0078	·018	·0078	·027	·037	·081
Phosphoric acid available.	·015	·018	·021	·004	·038	·136
Phosphoric acid total.	·080	·073	·036	·049	·069	·261
Potash available.	·0092	·0215	·0069	·0065	·0499	·166
" soluble in Hydrochloric acid.	·137	·461	·156	·336	·412	·979
Potash total .	2·230	2·809	2·917	1·845	2·422	2·529

THE EXHAUSTION OF INDIAN SOILS.

47. The question whether the soil of India generally is becoming exhausted has been raised and discussed by more than one person, and is the somewhat natural outcome of the fact, which is at once brought to the notice of any one who visits India, namely, that a large part of the cattle manure is used as fuel. Clearly on the face of it, if "exhaustion" be taking place, it is a slow process, and strictly speaking one could only determine the matter by very careful observation and experiment carried on for a long period. It will be equally clear that it would have been impossible for me in the few years at my disposal to attempt such a series of experiments.

S. 2260 a.

Indian Soils.	(J. W. Leather.) SOILS.
<p>At the same time since I have had an opportunity of spending several years in India, it will not be out of place if I set out very briefly the views on the subject which I have come to hold, views I may observe which are in most respects in accord with those expressed by Dr. Voelcker, but to which I shall add something.</p>	
<p>48. In the first place it will be well to refer for a moment to the opinion which Professor Wallace of Edinburgh (who spent 4 months in India in 1885 or 1886) expressed in his book entitled "<i>Indian Agriculture</i>." He says (chapter 13, page 158) "One very important question with regard to India still continues to be asked: Is the fertility of the soil being exhausted by the native practices that have been going on for thousands of years? My unqualified answer is "No." He then proceeds to explain what he refers to under the term "soil," and describes in detail the process of surface washing which occurs annually throughout India. He concludes the paragraph with the words "By cropping in the ordinary way the native fertility of a soil cannot be lowered." The following paragraph, however, makes an all important explanation of what Professor Wallace means by "native fertility." "Temporary fertility the qualities possessed in virtue of some accumulation of material useful to plants, may be dissipated, but when this is gone no system of cropping can reduce the land to a lower point. The greater portion of the land in India, which is not newly broken in, annually produces its minimum yield. Where declining fertility has been recorded, it was no doubt due to loss of temporary fertility which had accumulated during a period of rest." This second paragraph then contains the all important admission that although the fertility of Indian soil is not being exhausted, still it can become more fertile by rest, and that formerly it contained a store of <i>temporary</i> fertility which has now gone, and that the land has reached a certain level below which it cannot descend.</p>	<p>Professor Wallace's opinion.</p> <p>Fertility not being exhausted.</p> <p>Temporary fertility.</p>
<p>I may here observe with regard to the distinction which Professor Wallace makes between <i>temporary</i> and the <i>natural</i> fertility of soils, that it is one which no other authority on agricultural subjects (so far as I am aware) has expressed, and it is clearly only a question of <i>terms</i>. The <i>natural</i> fertility of a soil, which Professor Wallace says cannot be destroyed, certainly includes more than the mere rocky particles of which a soil is composed, for some organic matter is certainly</p>	
<p>S. 2260 a.</p>	

SOILS.	On the Composition of
Impossible to define temporary fertility.	<p>also a component part, and how one is to distinguish between this portion of organic matter belonging to the <i>natural</i> fertility, and that other portion of organic matter which belongs to Professor Wallace's <i>temporary</i> fertility, is a problem which it is quite impossible to solve, since they both are the product of the decay of plants or parts of plants in the soil. The presence of a store of "temporary" fertility in the past <i>may</i> or may not be the case; the opinion that a soil cannot be reduced in fertility below a certain level is one for which there is absolutely <i>no</i> proof; on the other hand, we have the <i>fact</i> that in the Rothamsted and Woburn Experimental Fields in England the crops which have been grown for so many years without the aid of manure do annually become less and less, and the limit (if there be one) has not so far been reached.</p>
Nitrogen in Rainfall.	<p>49. This fact is pointed out by Dr. Voelcker, and he further examines three questions which have a close relation to the main one. The first is "How much nitrogen is added to the soil by rain." The rainfall at Rothamsted brings annually about 4.5 lb of nitrogen to the land. For some time it was contended that the rain in India brought very much more than this, and figures, which were afterwards proved erroneous, were quoted in support of the fact. Later determinations by Dr. Van Geyzel of Madras showed in 1888 4 lb and in 1889 only 2.1 lb per acre of nitrogen to have been so deposited; later in 1891 Mr. Bamber, then Chemist to the Indian Tea Association, Calcutta, found that the nitrogen in the rain-fall from May to October was equal to 3.4 lb ammonia. Thus then it is practically certain that no large amount of this all-important plant food is added to the soil from this source.</p>
Rothamsted.	
Madras.	
Calcutta.	
Effect of growing pulses.	<p>The second point which bears upon the question is "What is the effect of growing such large quantities of pulses and other leguminous plants in India? What amount of nitrogen is supplied indirectly by this means to other crops?" Unfortunately, there is no answer to this question at present. All that one can say is that, knowing as we do that the members of this natural order <i>do</i> assimilate atmospheric nitrogen, they are a means of adding this plant-food to the soil, and doubtless it forms a very important item in relation to Indian agriculture.</p>
Effect of exporting grain.	<p>50. The third point which has been brought into the discussion is the effect of the export of grain, oil-seeds and bones from India.</p>

Indian Soils.

(J. W. Leather.)

SOILS.

Dr. Voelcker considers, as others have done, that this forms a serious loss. He says (para. 51) "On the one hand there is a large export of oil-seeds, cotton and other products besides an increasing one of wheat, all of which remove a considerable amount of the soil constituent. What is returned in their place? Only the straw or the stalks and leaves; and it is not even correct to say that these are returned, for, after all, it is only a portion, and frequently a very small portion, that does find its way back to the soil. Part is necessarily used up in the bodies of the cattle, part is wasted by imperfect conserving and storing of manure, part must unavoidably be lost, however great the care that may be taken; thus it comes about that it is only a fraction that contributes finally to making up the loss the soil has sustained. Were, on the contrary, all grain to be consumed by the people, and all night-soil to be used in agriculture; were all refuse of oil-seeds (after pressing out the oil) to be utilised for manure; were all straw to be consumed by cattle, and the droppings, solid and liquid together, to be carefully preserved; lastly, were all stalks and leaves to be buried again in the land, then the balance might be more nearly preserved. But, as things are, the exports of oil-seeds, grain, etc. (that of bones I will discuss later), simply mean so much of the soil constituents carried off, for which no adequate recompense is made.

To my mind this matter of export of agricultural produce has been gauged as far more serious than a consideration of the facts of the case will allow. In the paragraph just quoted from Dr. Voelcker's Report he says that if the residual matters of the crops produced in India were returned to the soil, the balance would be maintained, and it is clear that one may take this to be a fundamental fact. But it is also clear that export of agricultural produce out of India can only become a serious item *when it removes a material proportion of the plant-food which is extracted by each crop*. Now what is this proportion? In a paper entitled "*Memorandum on the Resources of British India*," Dr. Watt makes an estimate of 5,72,15,000 tons as the production of food grain, which however Dr. Watt does not consider very accurate. I myself think it may be somewhat too high. Nevertheless, it is not so utterly wrong as to be worthless for the purpose in question. The total exports of food grains is about 25,00,000 tons, or roughly 5 per cent. of the production, and accordingly some 5 per cent. of the plant-food which the grain of the crops annually extracts

Effect of
export pro-
bably over-
rated.

Reasons.

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SOILS.

On the Composition of

Actual
amount of
plant food
exported.

from the land is exported. Now what is the amount of plant-food which grain crops in India take up to form their substance? If we allow it to be some 15 lb. of nitrogen and half that amount of phosphoric acid per acre (which are the only items that need be taken into account) such an estimate cannot be considered too low; indeed it is in all probability too high. This is the amount, moreover, which is taken up by the whole crop (straw included). Since only grain is exported, it follows that it is not 5 per cent. of the abovenamed quantity, but 5 per cent. to a still smaller figure (probably $\frac{2}{3}$ or $\frac{3}{4}$ of it) which would represent the drain of these plant-foods per acre caused by export, or in other words it will not be much more than half a pound of nitrogen and quarter of a pound of phosphoric acid per acre per annum, and may be it is less than this! Such quantities as these are in all probability amply replaced by nature.

A similar result is obtained if one calculates, from the known amounts of nitrogen and phosphoric acid in the exported grain, the amount of these substances per acre. But by deducing the figures in the manner adopted, it is more clearly brought out how small a proportion of materials, required for the grain crops of India, are thus taken out of the country.

Loss made
up for by
natural
means.

It has already been mentioned that the rainfall brings down annually several pounds of nitrogen per acre and this agency alone much more than makes up for the loss of this element caused by export. And in the case of the phosphoric acid, the annual movement of silt from higher to lower ground on to the land by the monsoon rainfall must be admitted to be a source of mineral plant-food.

Thus there can hardly be any doubt that the export of food grain from India has been considered to be a far more serious drain than it really is.

Export of
bones.

And similarly in the case of bones, quite apart from the fact that at only one of the five experimental farms has this material been found of any value as manure, if the amount of phosphate exported be referred to the acreage, it will be at once evident how utterly impossible it is that this trade can be exercising any influence on the fertility of the land.

51. To my mind it is much more important to consider how the fertility of the land can be increased, than to consider whether the land is becoming exhausted. "Exhaustion" is a purely relative term; it is highly improbable that in any process of agriculture a certain level is finally reached below which fertility cannot descend, and it

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would be much more correct to say the fertility of the land in India is not only low compared with that of other countries, but that if it is not *decreasing*, it is certainly not *increasing*. It must also be admitted that with a better supply of manure fertility would be *immediately* increased and more grain produced per acre. And for that better supply of manure there is only one principal source, namely, the dejecta of the human beings and animals that consume very nearly the whole of the grain crops, straw included.

Fertility would be increased by manuring.

It is in the more perfect direct (not indirect) return to the land of these matters that one can look for an increased manure supply, an increased fertility, an increased outturn of food grain. Doubtless under present circumstances there are many difficulties to be overcome before anything like great economy will be realised in this direction. There is the scarcity of fuel which occasions the loss of nitrogen and organic matter of a very large proportion of the dung of agricultural animals ; there is doubtless a great deal of carelessness among cultivators (more in some parts than in others) as to the preservation of such refuse materials as are not burnt ; there is a similar want of method practised in relation to the night-soil. These difficulties may some day be removed. In the meantime they *must* remain an acknowledged fact, and that but for these obstacles the land *would* be more productive than it is. Further, so far as nitrogen is concerned, it may be kept in mind, that of the other two sources of this element, the rain is annually giving several pounds per acre, and that the LEGUMINOSÆ are also beneficial in a like direction. But to what extent they are thus beneficial is a problem which remains for future investigators to determine.

Importance of direct return to the land of animal fæces.

S. 2260 a.



(Medical and Chemical Series, No. 12.)
(Medicinal Products.)

THE
AGRICULTURAL LEDGER.

1898—No. 3.

ACONITUM FEROX.

(INDIAN ACONITE.)

[*Dictionary of Economic Products*, Vol. I., A. 397-400.]

CONTRIBUTIONS TO OUR KNOWLEDGE OF THE ACONITE ALKALOIDS.
ON PSEUDACONITINE.

By WYNDHAM R. DUNSTAN, M.A. F.R.S., and FRANCIS H. CARR, A.I.C., *Salters' Company Research Fellow in the Laboratories of the Scientific Department of the Imperial Institute. Reprinted from the Transactions of the Chemical Society, 1897.*

In previous papers communicated to this Society, an account has been given of an investigation of the principal properties and decomposition products of the alkaloid aconitine, derived from the roots of **Aconitum Napellus**. The enquiry has since been extended to a similar examination of the alkaloids occurring in other species and varieties of aconite. At the request of the Government of India, an investigation is being made, in the Scientific Department of the Imperial Institute, of the alkaloidal constituents of the chief kinds of aconite indigenous to India, especially of those which are highly poisonous, or are reputed to be of medicinal value. In this connection, Dr. H. A. D. Jowett has described (Part XIII of this series) the principal properties and decomposition products of *atisine* derived from the **Aconitum heterophyllum** of India. In a previous communication, and in the present paper, we give an account of pseudaconitine, the highly poisonous constituent of the aconite occurring in Nepaul, which is usually regarded as **Aconitum ferox**, and locally known as "*bish*" (*bikkh*). Our previous knowledge of this alkaloid is almost wholly due to the researches of Alder Wright, who, in conjunction with Luff, gave an account of its properties in a paper communicated to this Society in 1878. The material employed in our

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work consisted of roots of the plant, which were specially collected with great care in the Himálayas under the supervision of Dr. George Watt, C.I.E., the Reporter on Economic Products to the Government of India.

Pseudaconitine.

In a preliminary notice communicated to the Society two years ago (*Proc.*, June, 1895) the authors described some of the properties of pseudaconitine. They showed that its hydrolysis occurs in two stages, in the first of which acetic acid and a crystalline base veratryl-pseudaconine are formed, and in the second the elimination of a molecule of dimethylprotocatechuic acid takes place with the formation of pseudaconine. It has also been shown that, when pseudaconitine is heated in the dry state, one molecular proportion of acetic acid distils over, and a base is left, to which the name pyropseudaconitine was given. This base, when hydrolysed, furnishes dimethylprotocatechuic (veratric) acid and pyropseudaconine. The present paper gives a more detailed account of the experiments which furnished these results, and also an account of other observations on the properties of the salts and derivatives of pseudaconitine.

Extraction of the Alkaloid.—Several methods have been tried for the extraction of the base from the root, involving the use of methylic, ethylic, and amylic alcohols. Finally, a mixture of methylic and amylic alcohols, in the proportion of 5 to 1, was adopted as the most efficient solvent. The methylic alcohol is distilled from the slightly warmed percolate, under reduced pressure, when a quantity of fat separates; this is removed, and the alkaloid is extracted from the amylic alcohol by shaking it with very dilute (1 per cent.) aqueous hydrochloric acid. The solution is then shaken with ether, to remove the dissolved amylic alcohol, the alkaloid liberated by the addition of dilute ammonia, and then extracted by shaking with ether in the usual manner. On evaporating the dried ethereal solution, white crystals separate, which are recrystallised by dissolving them in dry chloroform, adding dry ether, and then dry light petroleum, until a slight turbidity is produced; by this means, a considerable supply of pure pseudaconitine was obtained. Judging from the yield obtained from the roots of **Aconitum ferox**, it would appear that more pseudaconitine is present in them than there is of aconitine in the roots of **A. Napellus**; but this is a question to which we shall return in a future paper.

Properties of Pseudaconitine.—The pure base crystallises well. Mr. W. J. Pope has kindly examined some fairly well-defined crystals, with the following results.

“The crystals of pseudaconitine consist of small, colourless, transparent crystals of rhomboidal shape having a rather vitreous lustre. Owing to the poor character of the images obtained from the various faces, the measurements given below are of no great accuracy; they would indicate that the crystals belong to the orthorhombic system. That the crystals are, however, not orthorhombic, is shown by the faces which they exhibit, and also by the interference

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Already
noticed.

Scope of this
paper.

Best solvent
for ext. ac-
tion.

Examination
of crystals.
Result.

Alkaloids.

(Dunstan and Carr.)

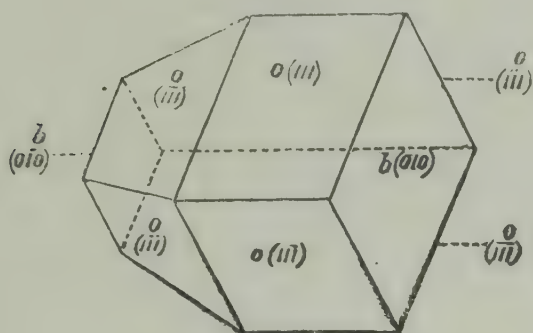
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ferox.PSEUDACONI-
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figure observed in polarised light. Considering, for the purpose of description, that the crystals are really orthorhombic, the following faces are always observed: —(010), (0 $\bar{1}$ 0), (111), (1 $\bar{1}$ 1), (1 $\bar{1}$ 1), (111), and (1 $\bar{1}$ 1), with traces of the form {110}; the two faces (1 $\bar{1}$ 1) and (111) are never observed. This observation was made on all the crystals examined—ten in number, belonging to two different crops—and the same faces of the forms {010} and {111} were found in every case; this arrangement of faces is not possible in the hemihedral subdivisions of either the orthorhombic or monosymmetric system. The crystals must, therefore, be assigned to the rare anorthic hemihedral system, two of the forms having the indices 111 being present as half-forms only, and the interaxial angles α , β , and γ being equal to 90° within the rather wide limits of error incurred in the measurement of crystals such as those now described.

“The crystals present the appearance shown in Fig. 1, and have the axial ratios—

$$a : b : c = 0.8362 : 1 : 0.6938.$$

FIG. 1.



“The following angular measurements were obtained:—

Angle.	No. of measurements.	Limits.	Mean.	Calculated.
$bo = 010 : 111$	23	$61^\circ 14' - 62^\circ 17'$	$61^\circ 54'$	—
$oo = 111 : 1\bar{1}1$	10	$54^\circ 27' - 56^\circ 46'$	$56^\circ 5'$	$56^\circ 12'$
$bo = 0\bar{1}0 : 111$	9	$117^\circ 26' - 118^\circ 19'$	$117^\circ 58'$	$118^\circ 6'$
$oo = 111 : 1\bar{1}1$	18	$67^\circ 12' - 68^\circ 59'$	$68^\circ 34'$	—
$oo = 111 : 1\bar{1}1$	7	$111^\circ 14' - 111^\circ 35'$	$111^\circ 24'$	$111^\circ 26'$
$oo = 111 : 1\bar{1}1$	8	$94^\circ 1' - 95^\circ 29'$	$94^\circ 35'$	$94^\circ 29'$
$oo = 111 : 1\bar{1}1$	4	$85^\circ 2' - 85^\circ 37'$	$85^\circ 20'$	$85^\circ 31'$
$pp = 110 : 1\bar{1}0$	4	$78^\circ 54' - 80^\circ 16'$	$79^\circ 20'$	$79^\circ 48'$
$pp = 110 : 1\bar{1}0$	1	—	$101^\circ 4'$	$100^\circ 12'$

“The crystals are very brittle, and possess a good cleavage; the latter, however, could not be determined. On examining a cleavage fragment under a very wide angle objective, one optic axis is seen to emerge at the edge of the field; it shows that the dispersion is inclined, which is only possible in the monosymmetric or anorthic

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system. The hemihedral character of the crystals is of interest, because non-superposable hemihedrism is so rarely observed on crystals of the natural alkaloids, that it has been said not to occur. (Wyrouboff, *Ann. Chim. Phys.*, 1894, [vii], 1, 11.)

"The crystalline form of aconitine has been determined by Tutton (*Trans.*, 1891, 59, 288), who found the crystals to be orthorhombic, but did not observe hemihedrism. Although morphotropic relationships would seem to exist between the crystalline forms of aconitine and pseudaconitine, yet these can hardly be worked out from the data now given for the latter alkaloid; the following corresponding angles on the two compounds seem to show some similarity.

Aconitine.		Pseudaconitine.	
100 : 121	60° 39'	010 : 111	61° 54'
010 : 121	57 42	100 : 111	55 43
001 : 121	46 33	001 : 111	47 15

Melting point.

The crystals melt with decomposition at 201°, acetic acid gradually distilling off; the melting point is fairly sharp if the substance is put into the bath heated to 150° and the temperatures slowly raised. Wright and Luff (*loc. cit.*) have recorded 104—105° as the melting point of pseudaconitine. They state that the alkaloid contains 1H₂O, which is lost at 100°, but we have not been able to confirm this observation. Pseudaconitine dissolves readily in alcohol, chloroform, and acetone, less readily in ether, very slightly in water, and scarcely at all in light petroleum.

Solvents.

Pseudaconitine is dextrorotatory. A determination of the specific rotatory power using an alcoholic solution, gave—

$$c = 1.12 \quad l = 2 \text{ dm.} \quad a = 25' \quad t = 15^\circ$$

$$\text{whence } [a]_D = \frac{100 \times 25}{2.1 \times 1.12 \times 60} = +18^\circ 36'.$$

The ordinary salts of pseudaconitine are lævorotatory, and usually soluble in water and alcohol. Combustion of the alkaloid made with the material dried at 100° gave the following results—

- I. 0.2617 gave 0.5964 CO₂ and 0.1691 H₂O. C = 62.29; H = 7.20.
 II. 0.2587 „ 0.5975 CO₂ „ 0.1484 H₂O. C = 62.96; H = 6.37.

Toxic properties.

These figures nearly correspond with those calculated from the formula proposed by Wright and Luff (*Trans.*, 1878, ii, 151), namely, C₃₆H₄₉NO₁₂, for which the calculated percentages are, for carbon, 62.88; for hydrogen, 7.13. Like aconitine, pseudaconitine and its salts, even in very dilute solution, give rise to a persistent tingling and numbing sensation on the tongue, and are highly poisonous. From preliminary experiments on the relative toxicity of various aconite alkaloids, which have been made at our suggestion by Dr. F. W. Tunnicliffe it would appear that pseudaconitine is slightly more toxic than aconitine.

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Alkaloids.

(Dunstan and Carr.)

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ferox.

Salts of Pseudaconitine.

Pseudaconitine hydrochloride, $C_{36}H_{49}NO_{12} \cdot HCl$.—We have not succeeded in obtaining this salt in a crystalline condition. It has been prepared by the direct action of dilute hydrochloric acid on both aqueous and alcoholic solutions of the base, but all attempts to crystallise it from water, alcohol, or a mixture of alcohol and ether have resulted in the production of a colourless varnish.

Pseudaconitine hydrobromide, $C_{36}H_{49}NO_{12} \cdot HBr$.—This salt is prepared by dissolving the base in dilute hydrobromic acid and evaporating the solution. A colourless varnish remains, and on adding a little alcohol to this, the mass rapidly becomes crystalline. It is best purified by dissolving it in dry alcohol and adding dry ether until a slight turbidity is produced; it then separates in large, cubical crystals often arranged in rosettes. The salt readily dissolves in alcohol and water, but is insoluble in ether and light petroleum. The crystals contain $2H_2O$, which are expelled on drying at $100-103^\circ$. The dried substance melts at 191° . The water of crystallisation was estimated by heating at $100-103^\circ$ in an air bath—

$$0.546 \text{ lost } 0.0263 = 4.8 \text{ per cent. } H_2O.$$

Determinations of the bromine in the undried and in the dried substance gave the following figures—

0.3379 undried salt gave 0.0751 AgBr. Br = 9.44.

0.5197 dried salt gave 0.1227 AgBr. Br = 10.05.

$C_{36}H_{49}NO_{12} \cdot HBr + 2H_2O$ requires $H_2O = 4.5$. Br = 9.95 per cent.

$C_{36}H_{49}NO_{12} \cdot HBr$ requires Br = 10.3 per cent.

An aqueous solution of the salt is lævorotatory; the determination of the specific rotatory power led to the following result—

$$a [15^\circ] = -15.6 \quad l = 2 \text{ dm} \quad c = 0.6635,$$

$$\text{whence } [a]_D = -\frac{100 \times \frac{15.6}{60}}{2 \times 0.6635} = -19^\circ 30'.$$

Pseudaconitine, therefore, resembles aconitine in being a dextro-rotatory base whose salts are lævorotatory.

Pseudaconitine hydriodide, $C_{36}H_{49}NO_{12} \cdot HI$.—This salt is precipitated in an amorphous condition when aqueous potassium iodide is added to an aqueous solution of pseudaconitine hydrobromide. Although at first amorphous, the precipitate rapidly becomes crystalline; it may readily be purified by recrystallisation from a mixture of alcohol and ether.

Pseudaconitine nitrate, $C_{36}H_{49}NO_{12} \cdot HNO_3$.—This salt was prepared by Wright and Luff (*oc. cit.*) by dissolving the base in dilute nitric acid, and precipitating the nitrate by adding strong nitric acid, in which it is only sparingly soluble; this method, however, is not to be recommended, as strong nitric acid is very apt to decompose the alkaloid. By dissolving the alkaloid in dilute nitric acid to exact neutrality, and evaporating to dryness, the nitrate is obtained as an amorphous varnish, which crystallises at once on the addition

PSEUDACONI-
TINE.

Not obtained
in crystalline
form.

Mode of pre-
paration.

Bromine.

Similarity to
aconitine.

The Nitrate.

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of alcohol; it is readily purified by crystallisation from a mixture of alcohol and ether, and when pure may be crystallised from water. The dried salt melts at 192° and effervesces at a slightly higher temperature; the melting point is fairly sharp if the substance is put into the bath at 155° and slowly heated. The water of crystallisation was determined by heating the powdered, air-dried salt at $100-105^{\circ}$.

0.1975 lost 0.014 H_2O . $H_2O = 7.0$ per cent.

$C_{86}H_{49}NO_{12} \cdot HNO_3 + 3H_2O$ requires $H_2O = 6.7$ per cent.

Its solubility in water at 15° was determined. 5 c.c. of a solution saturated at this temperature yielded, on evaporation, 0.209 gram of salt. 100 c.c. of water at 15° , therefore, dissolves 4.18 grams of salt.

Hydrolysis of Pseudoaconitine.

Acetic acid.

We have previously pointed out (*loc. cit.*) that, in addition to the pseudoaconine and veratric acid, observed by Wright and Luff, acetic acid is formed by the hydrolysis of pseudoaconitine, and we have also shown that the hydrolysis may occur in two stages. To determine the first stage only in the hydrolysis, namely, the elimination of acetic acid with the formation of veratrylpseudoaconine, it is best to employ a process similar to that which was found to answer in the case of aconitine. A neutral aqueous solution of a pseudoaconitine salt, preferably the sulphate, is heated in a sealed tube at 135° for 3 hours, the amount of acetic acid formed is determined by direct titration with N/10 alkali, and the alkaloid, after being liberated by the addition of sodium carbonate, is dissolved by shaking with ether.

A solution containing 0.168 gram of alkaloid (as salt), after this treatment, required for neutralisation 4.3 c.c. of N/10 alkali = 7.5 per cent. of acetic acid, which is slightly lower than that calculated for one molecular proportion, namely, 8.7 per cent.

Silver salt.

Analysis of the silver salt of this acid showed that it contained 64.56 per cent. of silver. Silver acetate contains 64.66 per cent. The formation of veratrylpseudoaconine may thus be represented by the following equations—

*Veratrylpseudoaconine.*Melting
point.

The pure base crystallises from ether in large, irregular crystals, which are nearly insoluble in water and in light petroleum, but readily soluble in ether, alcohol, and chloroform. They melt at 199° when put into the bath at 150° . A solution of the base is laevorotatory. A determination of the specific rotatory power in alcoholic solution led to the following results—

$$\begin{array}{l} t = 16^{\circ}, \quad a = -1^{\circ}16' \quad c = 1.5035 \quad l = 2.2 \text{ dm,} \\ \text{whence } [a]^D = \frac{100 \times 1.267}{2.2 \times 1.5035} = -38^{\circ}18' \end{array}$$

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Alkaloids.

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Rotatory
power.

Veratrylpseudaconine, therefore, unlike its analogue benzaconine, exhibits rotatory power of the opposite sign to that of its parent base. Aconitine and benzaconine are both dextrorotatory, whilst pseudaconitine is dextrorotatory and veratrylpseudaconine lævorotatory.

Combustions of the base, dried at 100—103°, furnished the following results, showing it to be a monhydrate—

- I. Carbon 61.44; hydrogen 7.15 per cent.
 II. „ 61.01; „ 7.05 „ „

Calculated for $C_{34}H_{47}NO_{11}, H_2O$: Carbon 61.54; hydrogen 7.39 per cent.

This alkaloid and its salts have a very bitter taste, but produce no tingling sensation, and do not appear to be poisonous.

Veratrylpseudaconine Hydrobromide, $C_{34}H_{47}NO_{11}, HBr$.—This salt separates from a mixture of alcohol and ether in large, prismatic crystals which contain $3H_2O$ —

0.3478 salt lost 0.0264 H_2O at 100°. $H_2O = 7.5$.

0.3478 „ gave 0.0842 AgBr. Br = 11.21.

$C_{34}H_{47}NO_{11}, HBr + 3H_2O$ requires $H_2O = 6.95$; Br = 11.02 per cent.

The salt is soluble in water, alcohol, and chloroform.

Veratrylpseudaconine nitrate, $C_{34}H_{47}NO_{11}, HNO_3$, crystallises from a mixture of alcohol and ether in rhombic prisms arranged in rosettes. In melting, two fairly sharp points may be noticed, one at 222°, when softening and change commences, and at 232°, when the salt melts sharply with decomposition. Combustion of the anhydrous salt gave C=57.34; H=6.40 per cent.: $C_{34}H_{47}NO_{11}, HNO_3$ requires C=57.62; H=6.77 per cent.

Veratrylpseudaconine aurichloride, $C_{34}H_{47}NO_{11}, HAuCl_4$, is thrown down as a pale yellow, amorphous precipitate when auric chloride is added to a solution of the hydrochloride. It is insoluble in water, ether, and light petroleum, but readily soluble in ethylic and methylic alcohols, chloroform, and acetone; it could not be crystallised from any of the last-mentioned solvents alone, or on the addition of any of the former to them.

Absence of
toxic
properties.Melting
points*Pseudaconine.*

The second stage of the hydrolysis by which veratrylpseudaconine passes into veratric acid and pseudaconine, may be best effected by adding alcoholic soda to an alcoholic solution of pseudaconitine, or veratrylpseudaconine. Hydrolysis takes place rapidly, and is complete in about 2 hours. Dilute sulphuric acid is then added, the filtrate evaporated, the veratric acid extracted from the acidified solution by ether, and the pseudaconine by chloroform, after rendering the solution alkaline with ammonia.

0.2143 gram of alkaloid gave 0.0556 gram of veratric acid = 25.94 per cent. Calculated for one molecular proportion, 26.49 per cent.

Hydrolysis

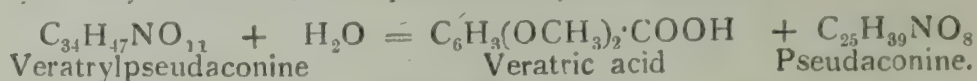
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The acid melts at 178° and exhibits the other properties of dimethylprotocatechuic acid (veratric acid). This stage of the hydrolysis may, therefore, be represented by the equation—



Pseudoaconine is an amorphous, hygroscopic base readily soluble in water, chloroform, alcohol and acetone, and less readily in ether. Its aqueous solution is strongly alkaline to litmus. All attempts to crystallise the base uncombined with its solvent have been unsuccessful.

An aqueous solution of pseudoaconine is dextrorotatory. The specific rotatory power of an aqueous solution was determined with the following results—

$$a[20^{\circ}] = +32.5 \quad c = 0.896 \quad l = 2 \text{ dm,}$$

$$\text{whence } [a] = \frac{100 \times 0.541}{2 \times 0.896} = +30^{\circ} 6'.$$

Pseudoaconine hydrochloride, $\text{C}_{25}\text{H}_{39}\text{NO}_8, \text{HCl}$, was prepared by dissolving the base in dilute hydrochloric acid to neutrality. Many attempts made to crystallise this salt from various solvents were unsuccessful, although, on one occasion, crystals were obtained from an alcoholic solution which had stood for six months; these were prisms and melted at 68° .

Pseudoaconine hydrobromide, $\text{C}_{25}\text{H}_{39}\text{NO}_8, \text{HBr}$, was prepared in the same manner as the hydrochloride, but it could not be crystallised.

Pseudoaconine nitrate, $\text{C}_{25}\text{H}_{39}\text{NO}_8, \text{HNO}_3$, was prepared by the direct action of dilute nitric acid on the base, and also by double decomposition between silver nitrate and the hydrochloride, and barium nitrate and the sulphate. It was always obtained in an amorphous state.

Pseudoaconine sulphate, $(\text{C}_{25}\text{H}_{39}\text{NO}_8)_2, \text{H}_2\text{SO}_4$, was prepared by acting on pseudoaconine with dilute sulphuric acid, but this salt could not be crystallised.

Pseudoaconine aurichloride, $\text{C}_{25}\text{H}_{39}\text{NO}_8, \text{HAuCl}_4$, is precipitated when auric chloride is added to a concentrated solution of pseudoaconine hydrochloride. It is a yellow, amorphous precipitate sparingly soluble in water, and could not be crystallised from any of its solutions. When light petroleum is used, the yellow colour of the solution is discharged and it becomes colourless, although no gold is precipitated. This change, in other cases, has been observed to be due to the production of an aurichlor-derivative by loss of hydrogen chloride from the aurichloride. We have so far failed to crystallise an aurichlorpseudoaconine from this solution.

Pyropseudoaconitine.

As previously recorded by us, when pseudoaconitine is heated slightly above its melting point, it effervesces and loses acetic acid. A determination of the amount of acetic acid which distils under these

A. 397-400.

Attempts at
crystallisation.

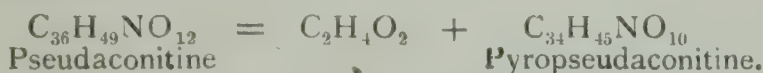
Behaviour
when heated
above melting
point.

Alkaloids.

(Dunstan and Carr.)

ACONITUM
ferox.

circumstances, proved that one molecular proportion of acetic acid is expelled; analysis of the silver salt of the acid proved it to be silver acetate. The reaction may, therefore, be represented by the following equation—



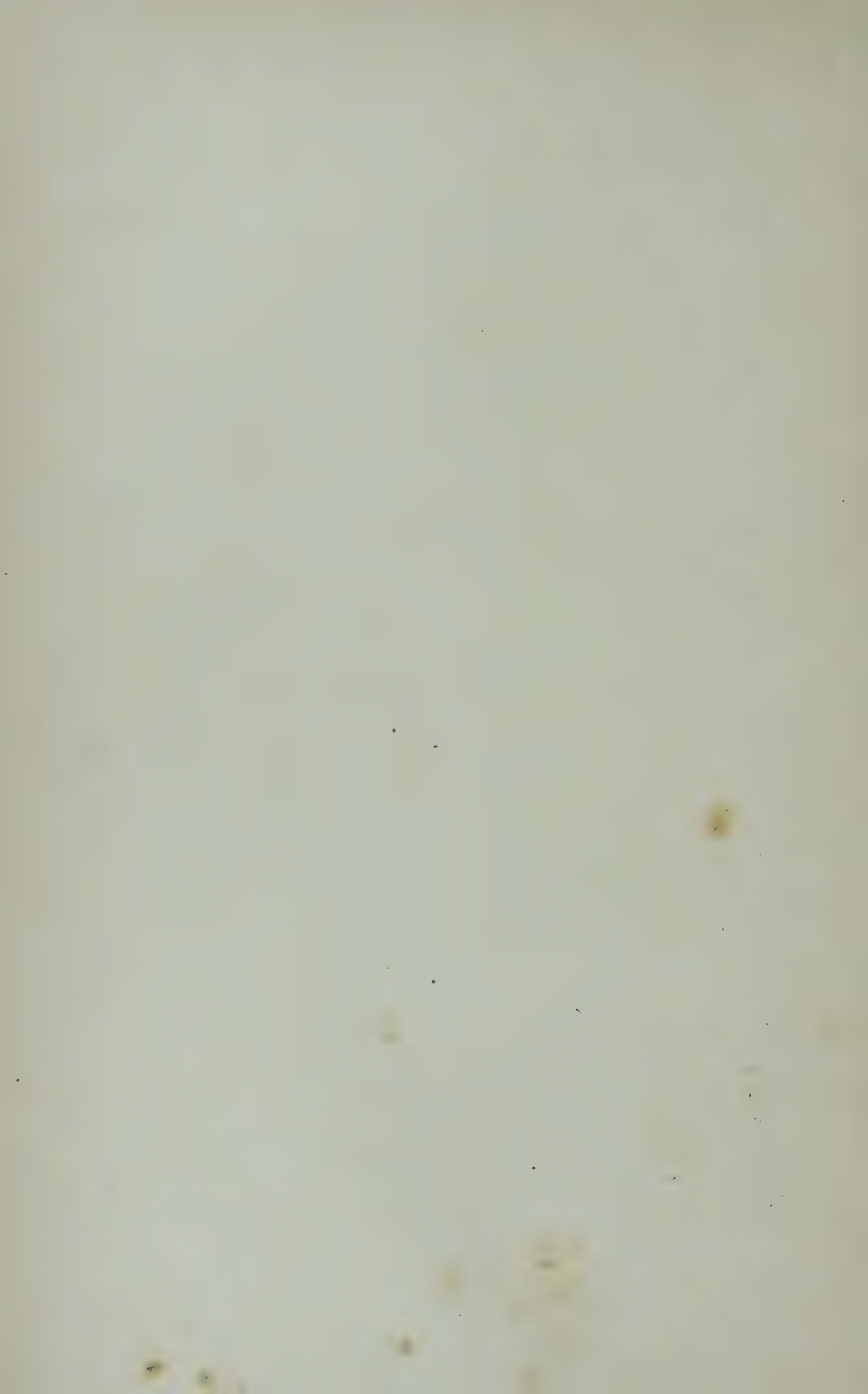
Pyropseudaconitine, an anhydride of veratrylpseudaconine, is obtained from the residue by solution in dilute acid, and is purified by fractional precipitation from this solution with dilute ammonia. The colourless fractions are dissolved in dilute acid, precipitated with ammonia, and the pure base extracted from the alkaline solution by ether. The base so far has only been obtained as an amorphous varnish, nearly insoluble in water, but readily soluble in alcohol, chloroform, and ether. Its salts appear to crystallise well; they have a bitter taste, but produce no tingling, and do not seem to be poisonous. The *hydriodide* crystallises in prisms.

Although, in publishing our preliminary notice of pseudaconitine we stated that we were engaged in a complete investigation of the alkaloid, this did not prevent Herr Martin Freund from examining the alkaloid, and, nine months after the appearance of our paper in the Proceedings of this Society, publishing in the "*Berichte*" (*Ber.*, 29, 6, 852) an account of his and Herr Niederhoffheim's experiments on the subject. They adopt Wright's formula for the alkaloid, and confirm our conclusion that pseudaconitine, like aconitine, contains an acetyl group. For the rest, they record melting points which differ somewhat from those previously recorded by us, but since these points are in most cases decomposing points, and depend on the conditions under which the observations are made, no real importance attaches to these discrepancies.

As to their assertion that pseudaconine is the anhydride of the aconine derived from aconitine, it is to be observed that this statement is based solely on the numerical coincidence that the formula for pseudaconine deduced from Wright's formula for pseudaconitine, namely, $\text{C}_{25}\text{H}_{39}\text{NO}_8$ differs by one molecule of water from the formula which Freund has suggested for aconine ($\text{C}_{25}\text{H}_{41}\text{NO}_9$). But, as we have elsewhere pointed out, Freund's new formulæ for aconitine and its derivatives cannot at present be accepted as proved, and we have so far seen no reason to depart from a formula for aconitine, differing very slightly from that originally suggested by Wright, which does not allow of pseudaconine ($\text{C}_{25}\text{H}_{39}\text{NO}_8$) being regarded as the anhydride of aconine ($\text{C}_{25}\text{H}_{39}\text{NO}_{10}$). As a matter of fact, we have already described an anhydride of aconine (pyraconine), whose properties are very different from those of pseudaconine.

We have pleasure in acknowledging the skilful help afforded us in the early stages of this work, in the Research Laboratory of the Pharmaceutical Society, by Mr. H. T. Durant.

PSEUDACONI-
TINE.Apparent
absence of
toxic pro-
perties.Another
account con-
sidered.



(Veterinary Series, No. 26.)

THE
AGRICULTURAL LEDGER.

1898—No. 5.

OXEN.

(CATTLE DISEASES.)

[*Dictionary of Economic Products*, Vol. V., O. 590-94.]

PROFESSOR KOCH'S METHODS OF IMMUNISING CATTLE AGAINST
RINDERPEST.

Reports by DR. A. LINGARD, *Imperial Bacteriologist to the Government of India*,
VETERINARY-LIEUTENANT F. S. H. BALDREY, *Assistant Principal, Bombay*
Veterinary College, VETERINARY-CAPTAIN W. R. HAGGER, *Principal, Ajmere*
Veterinary School, VETERINARY-CAPTAIN H. T. PEASE, *Principal, Veterinary*
College, Lahore, VETERINARY-CAPTAIN F. RAYMOND, *Superintendent, Civil*
Veterinary Department, Bengal, VETERINARY-CAPTAIN G. H. EVANS, *Super-*
intendent, Civil Veterinary Department, Burma.

Extract from the Proceedings of the Government of PREAMBLE.
India, Department of Revenue and Agriculture,—
No. 8/94-8, dated 5th May 1898.

Read—

Letters from the Inspector General, Civil Veterinary
Department, Nos. 173—191, 755 C., and 218-114,
dated, respectively, the 6th August, 13th November
and 29th December 1897, submitting reports by the
undermentioned officers on Dr. Koch's methods of
immunising cattle against rinderpest.

Reports by Dr. A. Lingard, Imperial Bacteriologist to
the Government of India; Veterinary-Lieutenant

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RESOLUTION of the GOVERN- MENT of INDIA.	F. S. H. Baldrey, Assistant Principal, Bombay Veterinary College; Veterinary-Captain W. R. Hagger, Principal, Ajmere Veterinary School; Veterinary-Captain H. T. Pease, Principal, Veterinary College, Lahore; Veterinary-Captain F. Raymond, Superintendent, Civil Veterinary Department, Bengal; Veterinary-Captain G. H. Evans, Superintendent, Civil Veterinary Department, Burma.

RESOLUTION.

When Professor Koch, the eminent Bacteriologist, visited India in the summer of 1897, he expressed his willingness to demonstrate the methods of immunising cattle against rinderpest, which he had practised during his investigations into the disease in South Africa. The Government of India gladly availed themselves of Professor Koch's generous offer, and arranged with Local Governments that the Imperial Bacteriologist and officers of the Civil Veterinary Department should attend the demonstrations which were to be carried out at the Bacteriological Laboratory at Muktesar in the North-Western Provinces. Professor Koch, accompanied by Dr. Lingard and Veterinary-Captain Pease, first visited some villages in the North-Western Provinces, where outbreaks of rinderpest had occurred, for the purpose of procuring material for his experiments, and then went to Muktesar, where he gave complete demonstrations of his system of immunisation.

2. The importance of these demonstrations can hardly be exaggerated in view of the great loss caused annually by rinderpest in India; and Professor Koch has placed at the disposal of the Government of India, in the freest possible manner, and at considerable personal inconvenience, all the results of his knowledge and experience of this most fatal scourge.

3. All the officers present at the demonstrations have submitted reports giving an account of the

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methods adopted by Professor Koch, and as these contain many valuable suggestions, it has been decided to publish extracts from them in the Veterinary Series of the Agricultural Ledgers. The Government of India also consider it desirable that the attention of Local Governments should be specially directed to certain points in the reports which are deserving of special notice.

RESOLUTION
of the
GOVERN-
MENT of
INDIA.

4. The report of the Principal of the Lahore Veterinary College shows that Professor Koch's method could not well be utilised in the case of outbreaks in the districts in view of the fact that his process of immunising takes quite ten days, and that before this time had elapsed an animal exposed to contagion would be likely to contract the disease. This is a matter of no small importance, but it is believed that more practical methods are already being adopted in South Africa, and experiments are now being carried on by the Imperial Bacteriologist which, it is hoped, will result in the discovery of a method more suited to the requirements of this country. But meanwhile the Government of India ask for the hearty co-operation of Local Governments and Administrations in the carrying out of experiments in different parts of the country, more especially in the districts in the plains. The necessity for such experiments is clear, whilst the account of the experiments carried out by Veterinary-Captain Raymond in Bengal shows how much can be done by officers possessing the necessary qualifications. Sindh would also appear to be a favourable field, and the Government of India will be glad if it is found possible to make experiments there. The Government of India feel assured that Local Governments will encourage experiments wherever it is possible to carry them out by properly qualified agency and without the risk of creating new centres of infection.

5. Another point which is of special importance with reference to the hide trade of India is referred

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OXEN.	Professor Koch's Methods of	
RESOLUTION of the GOVERN- MENT of INDIA.	<p>to in the report of the Principal of the Lahore College. Veterinary-Captain Pease shows how hides may be rendered inert, and his recommendations on this subject appear to be well worthy of careful consideration.</p>	
	<table border="0"> <tr> <td> <p>Government of Madras. " Bombay. " Bengal. " North-West- ern Provinces and Oudh. Government of Punjab. " Burma. Chief Commissioner, Central Provinces. Chief Commissioner, Assam. " " Coorg. " " Ajmere- Merwara. Resident, Hyderabad.</p> </td><td> <p>ORDER.—Ordered, that a copy of the above Resolution be forwarded to the Local Governments and Administrations noted in the margin, for information.</p> </td></tr> </table> <p>Ordered also, that a copy be forwarded to the Inspector General, Civil Veterinary Department, for information.</p> <p style="text-align: right;">[True Extract.]</p> <p style="text-align: right;">DENZIL IBBETSON, <i>Secretary to the Government of India.</i></p> <hr style="width: 20%; margin: 20px auto;"/> <p>1. In accordance with the foregoing Resolution of the Government of India, the following Reports, or Extracts from Reports, are now printed.</p> <p>2. Dr. Lingard, the Imperial Bacteriologist, reports as follows :—</p> <p>O. 590-94.</p>	<p>Government of Madras. " Bombay. " Bengal. " North-West- ern Provinces and Oudh. Government of Punjab. " Burma. Chief Commissioner, Central Provinces. Chief Commissioner, Assam. " " Coorg. " " Ajmere- Merwara. Resident, Hyderabad.</p>
<p>Government of Madras. " Bombay. " Bengal. " North-West- ern Provinces and Oudh. Government of Punjab. " Burma. Chief Commissioner, Central Provinces. Chief Commissioner, Assam. " " Coorg. " " Ajmere- Merwara. Resident, Hyderabad.</p>	<p>ORDER.—Ordered, that a copy of the above Resolution be forwarded to the Local Governments and Administrations noted in the margin, for information.</p>	

Immunising Cattle against Rinderpest.

OXEN.

DR. LINGARD'S REPORT.**DR.
LINGARD'S
REPORT:**

In accordance with your deferred telegram, dated Simla, 5th May, 1897, received by me at Jainti, Hathipoda, North-East Bengal, at 5 P.M. on May 9th, 1897, I started for Bombay on the same date at 7 P.M., and arrived on May 16th.

2. On receipt of your letter No. 474—191 M., with instructions, I at once placed myself in direct communication with Professor Koch.

The outcome of our several meetings was that Professor Koch kindly offered to demonstrate the steps of his protective system against rinderpest in cattle, if he might be allowed to obtain the material at the seat of an outbreak of the disease and conduct his demonstrations at Muktesar Laboratory.

3. After having informed you by wire of the Professor's proposals, I followed out your instructions to obtain information concerning outbreaks of rinderpest as near as possible to the Laboratory.

For this purpose I put myself in communication with the Superintendent, Civil Veterinary Department, North-Western Provinces, and later ascertained that outbreaks of the disease were present in the districts of Barabanki and Fyzabad (Partabgarh and Akbarpur). Permission by wire having been obtained from His Honour the Lieutenant-Governor of North-West Provinces.

4. After making the necessary arrangements in Bombay, Professors Koch, Gaffky and Pfeiffer left Bombay with me on the 26th of May and proceeded at once to Lucknow, where we arrived on the 28th. From this station telegrams were despatched to different District Officers, and information received as to the best locality to visit for our purpose. On the morning of the 30th May, in consultation with the district authorities at Fyzabad, we left Lucknow for that station with a view to visiting Akbarpur, where a rinderpest outbreak had been reported to exist.

Information having been received by the Deputy Commissioner during the day, concerning cattle disease in the Akbarpur Tehsil, tents and other necessities were despatched by his orders to Akbarpur to await our arrival on the following morning.

5. On the 31st we proceeded by rail to the above station. The Veterinary Assistant of the district met us there, and informed us that rinderpest was supposed to be present in the villages near Tanda, some 12 miles distant. And after corroborating the same, we made arrangements for leaving the station early on the following morning.

6. On our arrival at Tanda on June the 1st, the Veterinary Assistant was despatched to visit certain villages with a view to discovering cases of the disease. On his return with information as to the presence of cattle plague, we proceeded to the village of Rajipura and there found several head of cattle and buffaloes suffering from rinderpest and the carcasses of one which was said to have succumbed about half an hour.

Professor Koch made the autopsy on the animal, and subsequently expressed it as his opinion that "the pathological changes found

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in the intestines, were identical with those found by him in animals dead of rinderpest in South Africa, and therefore the Indian and the South African diseases are identical." At the same time the Professor collected blood from the heart in sterilised flasks, which he defibrinated *in vitro*. He also collected bile from the gall bladder into similar vessels. These vessels were subsequently placed in ice.

Early on the following morning we again visited the same and other villages with a hope that we might obtain another autopsy; however, as no animal had succumbed to the disease during the night, we collected specimens of nasal and lachrymal discharges, together with small quantities of faecal matter and mucus passed, respectively, by a buffalo and a bull, suffering from rinderpest.

On our return the whole of our specimens were deposited in a tin box which was surrounded entirely on all sides with thick slabs of ice, and we proceeded to the Laboratory at Muktesar with the utmost despatch.

7. The conclusions * Professor Koch arrived at, at the termination of his experiments with regard to rinderpest in South Africa, were as follows :—

- (a) The best method of transmitting rinderpest from one animal to another is by means of subcutaneous injection of virulent defibrinated blood, for by this means blood can be taken from animals during the earlier stages of the disease, when it does not contain any septic matter, but simply the contagium of rinderpest. Another great point in favour of using virulent rinderpest blood for the above purpose, is the important fact that a form of disease is produced with an incubation period of from three to five days.
- (b) One five-hundredth of 1 c.cm. of virulent rinderpest blood produced rinderpest in an animal after exactly the same time and manifested the same malignant symptoms as those animals which had received 10 c. cm., a dose 5,000 times larger. And later Professor Koch heard from South Africa that the inoculation of $\frac{1}{1000}$ th of 1 c. cm. of blood had produced a like result.
- (c) Glycerine, when mixed with virulent rinderpest blood, exercised a destructive effect upon the rinderpest virus.
- (d) Distilled water, mixed with virulent rinderpest blood, delayed the symptoms of the disease, but later the symptoms appeared and the disease was just as violent and fatal as in the ordinary spontaneous cases of rinderpest.
- (e) Virulent rinderpest blood is destroyed by prolonged exposure (four hours) to a temperature of 31°C. (87·81°F.); when injected into cattle, however, it produces "no protective action."

* Collated from Professor Koch's *interim* reports published in South African newspapers.

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Immunising effects of Bile.

8. Immunity from rinderpest is conferred upon cattle after the subcutaneous injection of 10 c. cm. of bile taken from the gall bladder of an animal which has succumbed to a virulent attack of rinderpest.

"This immunity sets in on the 10th day at latest, and is of such an extent that even four weeks afterwards 40 c. cm. of rinderpest blood could be injected without any injurious result. I therefore conclude that the immunity produced in such manner is of an 'active' nature."

Experiments, however, have proved that an injection of less than 10 c. cm. rinderpest bile is insufficient to render cattle immune against rinderpest.

"The local result of an injection is merely a hard, somewhat painful, swelling of the size of a man's fist, which sometimes causes lameness for a few days, but gradually disappears in the course of a few weeks, provided, however, that the bile is not in a stage of decomposition, as is not uncommon, when an animal suffers from rinderpest. Under these circumstances, an abscess may form, which, however, does not seem to be detrimental to the process of immunisation."

"The protective properties of the bile will be of inestimable service in infected parts. Nearly every case of rinderpest supplies a greater or lesser quantity of vaccine for those animals which are still healthy."

9. Regarding the immunisation from rinderpest, Professor Koch remarked, "I undertook many experiments for the purpose of ascertaining the best manner in which the bile is to be employed, and to investigate the nature of this remarkable process."

"First, a control experiment was made with the bile of a sound animal. The result was, that such a bile had no immunising effect whatever. Also the bile of an animal suffering from rinderpest is as such by no means effective when taken from a rinderpest animal, that was killed on the 3rd day after the observed rise of temperature, and did not protect the injected animal against the disease. Even the bile from animals which survived the attack of rinderpest proper, but were suffering from secondary disease and died from such causes, was of a very doubtful or no protective value. The best results I always obtained were with bile as used at 'Susanna' farm and the qualities of which I characterized in my description of these experiments."

"For theoretical reasons I made an experiment by mixing larger and smaller quantities of virulent rinderpest blood with the rinderpest bile and thereby got the important result that the bile is able to make a considerable quantity of rinderpest blood innocuous, provided both fluids are properly mixed. In one case 5 c. cm. bile and 5 c. cm. blood were injected and the animal became immunised by this treatment."

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<p>DR. LINGARD'S REPORT.</p>	<p>"It appears that an admixture of rinderpest blood with rinderpest bile even increases the immunising qualities of the latter, and I do not consider it improbable that less effective rinderpest bile, <i>i.e.</i>, bile taken from the animals at the beginning of the disease, may be transformed in this way into an effective medium, and that even the bile of sound animals might be used by such a process for the same purpose. Experiments in connection with the hypothesis are not ended as yet, and the matter is at present only in a state of investigation. Should these experiments give a good result, it would then be an easy matter to prepare at any time large quantities of a highly immunising and uniformly acting protective medium. In practice, these experiments are so far of importance, as is herewith clearly proved, that contamination of the bile with blood must by no means be scrupulously avoided."</p> <p>10. "Four animals were injected with 10 c. cm. of bile taken from an animal that had died at the 'Susanna' farm. Of these, No. I was re-injected with virulent blood on the second day after the first injection. No. II on the fourth, No. III on the sixth, No. IV on the eighth day after the first injection."</p> <p>"No. I fell sick and died, as if no protective inoculation had taken place.</p> <p>"No. II fell sick with slight symptoms of rinderpest, but soon recovered.</p> <p>"No. III and No. IV exhibited no symptoms of any disease whatever. They proved themselves so strongly immunised that a subsequent injection of 20 c. cm. of fresh rinderpest blood produced no reaction of any kind. In accordance with these facts, the conclusion may be drawn that immunity began on the sixth day after the application of this bile."</p> <p>11. "To ascertain whether smaller doses like 10 c. cm. were sufficient to create immunity, I injected three cattle with 1, 2 and 5 c. cm. of rinderpest bile each, and applied ten days later 0.2 c. cm. rinderpest blood. All these animals fell sick subsequently with severe symptoms of rinderpest, one inoculated with 5 c. cm. recovered, the other two died; it may, therefore, be concluded with safety that an injection with less than 10 c. cm. rinderpest bile is insufficient to render cattle immune against rinderpest."</p> <p><i>Immunising power of injections of Blood serum from Rinderpest Animals.</i></p> <p>12. "The protective properties of blood serum are not very great, for 100 c. cm. of such serum are required to protect an animal against an inoculation with a small dose of rinderpest blood. This immunity is in its nature merely a 'passive' one, and will only last during a short period."</p> <p>"This method may be used in order to separate from infected areas those tracts of country which are still free from the scourge, by means of forming a broad belt between them in which all the cattle are inoculated with the vaccine."</p>

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"For protective inoculation on a large scale the above serum is not applicable, but by means of a mixture of *serum and virulent rinderpest blood* I succeeded in immunising within a fortnight several animals to such a degree, that they were enabled to withstand an injection of 20 c. cm. rinderpest blood $\frac{1}{1000}$ th part of which is a fatal dose."

"From this fact, I judged that the immunity of these animals is of a much higher degree, and I believe it is an 'active' immunity, equal to that of a beast which has contracted rinderpest and recovered."

13. "To prepare the above serum from 'salted' animals, the blood is taken from the jugular vein and is conveyed into an air-tight bottle. It is then allowed to remain for 24 hours in a place kept as cool as possible and not disturbed. The fibrin and serum will then be found to have formed."

"The latter is to be taken off with a syphon and mixed immediately with fresh rinderpest blood in the proportion of 1 : 100 c. cm., i.e., for each 99 parts of serum one part of fresh blood. This mixture is kept for about 12 hours in a place at the usual temperature and is shaken from time to time. After the lapse of this time, the animals to be rendered immune are injected into the dewlap with 20 c. cm. of this mixture. In this way a certain basis of immunity is obtained. Although considerably less effective than the gall injection, the state of immunity may soon be raised by further injections with blood. For this purpose I gave on the seventh day after the first injection, 1 c. cm. and again seven days later 20 c. cm. of fresh blood. To preserve this serum for a certain time with all its immunising qualities, I did unfortunately not succeed, except by keeping it in the ice box."

14. "Should the necessity arise to employ the serum in a preserved state, there will be no other way but to dry it in the vacuum apparatus, a treatment which gave most satisfactory results with other kinds of serum."

Method of collecting Bile.

15. The autopsy should be held on the 6th* day or as soon after the animal succumbs to rinderpest (seventh or eighth day) as possible.

16. The animal is laid on its left side, an incision is made in the flank from the vertebral column down along the posterior border of the ribs, and from thence posteriorly along the median line of the abdominal wall. After carefully opening the peritoneal cavity at one point, insert the fingers of the left hand and cut through the abdominal muscles along the line, before indicated; at the same time raising the tissues to avoid wounding the organs with the knife. On reflecting the above flap the gall bladder will be exposed to view.

An Assistant, whose hands have been previously washed in sublimate solution (1 in 1,000), takes hold and raises with his left hand

* In South Africa Professor Koch slaughtered rinderpest animals for bile on sixth day of the disease.

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<p>DR. LINGARD'S REPORT.</p>	<p>the free border of the ribs, while with the right he grasps the gall bladder, placing the palm of the hand under it, and by gentle pressure forces the contained fluid towards the fundus of the organ. The person about to collect the bile should make a small vertical incision with a sterilised scalpel at the most dependent part of the bladder, and so allow the bile to flow into a sterilised vessel, fitted with glass stopper or cotton-wool plug.</p> <p>After collection, the bile should be placed in an ice chest or cool cellar, until required.</p> <p><i>Operation necessary for the collection of blood from the jugular vein of an Animal.</i></p> <p>17. The animal is thrown down in the usual manner, the feet being securely fastened together. A block of wood some 5 or 6 inches in thickness is placed under the neck in order to raise and extend the skin over the seat of operation. The exact spot for the incision is found by bending over the ear along the course of the jugular vein, the incision being made at the point where its tip reaches. After cleaning the surface of skin and washing it with a solution of sublimate (1 in 1,000), pressure is put on the jugular vein, low down in the neck, when the course of the vessel comes rapidly into view. An incision $1\frac{1}{2}$" long is made through the skin transversely to the axis of the vein at the above-mentioned spot. An electro-plated canula is then pushed gently through the wall of the vein and the blood is caught in sterilised flasks. On withdrawal of the canula slight pressure is exercised for several minutes, with a pledget of cotton-wool saturated with sublimate solution, after which, as a rule, all hæmorrhage ceases. One or two sutures are then placed in the skin wound, and after thoroughly washing the surface of the skin, the animal is removed.</p> <p><i>Injection of Bile or Blood.</i></p> <p>18. The animal is thrown down in the usual manner, and the four feet securely fastened. A portion of skin selected to receive the injection, covering the anterior extremity of the sternum or of the dewlap, is grasped between the fore-finger and thumb of the left hand and slightly lifted up from the underlying tissues. The needle of the syringe containing the fluid to be injected is then inserted into the depressed skin between the tips of the finger and thumb, and with a boring motion, if from the thickness of skin any difficulty in piercing it is experienced. Care should be taken that the needle passes into the subcutaneous tissues and not into the underlying muscle. It is always as well to feel that the needle is free, before forcing the bile or blood, from the injection syringe. When removing the needle, still retain hold of the integument with the left fore-finger and thumb, and, after withdrawing it, grasp the skin at the point of exit of the needle with the right hand, whilst with the left manipulate the small subcutaneous tumour with a view to the dispersal of the injected fluid.</p> <p>O. 590-94.</p>

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19. Having now given the results obtained by Professor Koch and the technique of the different operations, it is necessary to enumerate the requirements in order that use may be made of the bile protective system :—

- (a) Virulent rinderpest material.
- (b) Inoculation of animal for bile.
- (c) Injection of bile into animals.
- (d) Animals undergo proof with virulent rinderpest blood.

(a) Virulent rinderpest blood is required for the inoculation of cattle in any district, unless the disease already exists in a virulent form.

(b) Inoculation of animals with rinderpest blood, in order that they may pass through the malady and be destroyed on the proper day of the disease, for the purpose of collecting bile. If the operation is postponed until directly after the death of the animal, the bile can only be utilised when obtained from those animals which succumb to a virulent attack on the seventh or eighth day, but not later. The best bile when drawn from a rinderpest animal dead of the disease presents a green colour and few, if any, micro-organisms. Frequently, however, this fluid is found to present a yellowish green or brownish green appearance by transmitted light, and it is then generally found not to possess the high immunising power of the green bile and microscopically, more septic organisms.

The best bile for protective purposes found by Professor Koch in South Africa was that obtained on the sixth day after the rise of temperature, and from this he proved that bile (aseptic at time of collection), when kept in ice, preserved its protective power for a period of 14 days; in fact, its immunising power, when injected into animals, was found to be just as high at the end of the 14 days as at the time of collection.

(c) Inoculation of animals with approved bile—Ten cubic centimetres is the smallest amount which should be injected into each animal, and all bile should be carefully examined microscopically and any micro-organisms found in the fluid noted, not only as soon after collection as possible, but before using it at any later date, for, considerably more swelling takes place at the seat of injection with bile which contains organisms when collected directly after death, and which is kept for subsequent inoculation purposes.

(d) It is essential that animals injected with bile for protective purposes, should be proved by inoculation of virulent rinderpest blood at a later date.

Previously it has been pointed out that the immunity conferred by the injected bile sets in on the tenth day at latest in South Africa, and therefore this day was chosen for the proof experiment.

RESULTS OF EXPERIMENTS UNDERTAKEN AT MUKTESAR, 7,500 FEET ELEVATION ABOVE SEA-LEVEL.

20. With the rinderpest material brought from Tanda it was the intention, if possible, (a) to reproduce the disease by inoculation of

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blood, in order to obtain a supply at a later date for proving the immunising power of the bile; (b) to reproduce the disease with nasal discharge and dung; (c) to protect animals against rinderpest by the subcutaneous injection of bile, and other modified processes.

The following précis of the cases will show the course the disease followed in the animals inoculated.

Blood.

21. Immediately on our arrival at the Laboratory on June 4th, 7 P.M., two bullocks, Nos. I and II, were each inoculated in the dewlap with 10 c. cm. of the defibrinated blood.

No. I.—This animal's temperature attained 104° F. on the fourth day after inoculation and 105·8° F. on the evening of the sixth. Severe symptoms set in—purging, etc., and death took place on the morning of the tenth day from the time of inoculation.

On the fifth day of the disease with a temperature of 105° F. blood was let, and two animals, Bull No. XI and Cow No. XII, were inoculated with 10 c. cm. each. The *post-mortem* disclosed the usual marked pathological changes found in rinderpest.

No. II.—The temperature rose to 104° F. on the evening of the fourth day and to 105·6° F. on the seventh day after inoculation. This animal presented all the well-marked symptoms of rinderpest, but instead of death following a rapid fall in the temperature on the seventh and eighth day of the disease, death took place on the sixteenth day after inoculation. A gradual fall in the temperature, from 104·7° F. to 91·6° F., when death occurred, occupied eight days.

No. XI.—Was inoculated with 10 c. cm. of blood drawn from the jugular vein of No. I on the 11th June. The temperature rose somewhat suddenly to 105·8° F. on the 15th and attained the maximum 106·5° F. on the 19th, the fourth day of the disease. This animal passed through a smart attack of rinderpest, the temperature falling to normal on the seventh day of the disease; but up to this blood was still passed with the dung. The animal has now recovered. No. XIX Bull was inoculated on the 21st June with blood drawn from the jugular vein of No. XI.

No. XII Cow.—First rise fourth day after inoculation; recurrent fever until morning of the seventh day of disease. Temperature normal. This animal passed through a very smart attack of the disease 'diarrhoea,' cough being a most troublesome symptom; mucus and blood still passed on the fourteenth day of the disease, July 11th; has now recovered.

No. XV Buffalo.—This experiment was made with a view to discover what course rinderpest takes in the Buffalo, and when inoculated from bovines, whether the virulence of the disease is increased or diminished. It was inoculated with 10 c. cm. of defibrinated blood taken from the heart of Bullock No. I at *post-mortem*, and inoculated five hours after death. A slight thickening occurred at the seat of inoculation, but it had entirely disappeared after 24 hours. The rise in temperature did not occur until the

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eighth day after inoculation; maximum 105.8°F . attained on second day of disease, and normal temperature again recorded on the 4th day of the disease. A trace of blood and mucus was passed 'per anum' at the time of the first rise in temperature, but only slight diarrhoea followed, and the animal was never entirely off its feed. This animal was inoculated as control to cases Nos. V and VI, first inoculation with bile.

Blood was taken from the jugular vein on the 25th June, and 10 c. cm. inoculated into No. XXII.

No. XIX Bull—Inoculated with 10 c. cm. blood taken from the jugular vein of Bull No. XI, *ante-mortem*. This animal presented a few symptoms of rinderpest, *viz.*, shivering, high temperature on two occasions, blood-stained dung, etc., but the attack was only very slight and the animal was never off its feed. This animal was inoculated as a control experiment to Cows Nos. VII, VIII, IX and X on the 21st June 1897.

No. XXII Bull—Was inoculated on June 25th, 1897, with 10 c. cm. of blood taken from the jugular vein of Buffalo No. XV. The temperature began to rise on the fourth day after inoculation and attained a maximum of 107.9°F . on the fourth day of the disease, after which it declined; by the 7th day of disease, registered 99.7°F . Dullness and loss of appetite were the most marked symptoms, but the attack of rinderpest was very slight.

Bile.

22. On June 6th, 1897, at 4-30 P.M., two animals, Cow No. V and Bull No. VI, were each injected with 10 c. cm. of bile collected from an animal which succumbed to rinderpest, near Tanda, at 7 P.M. on June the 1st, and therefore 120 hours old. On the 14th June at 5 P.M. each animal received subcutaneously 10 c. cm. of defibrinated blood taken from the heart of Bullock No. I, in order to prove whether the injected bile had conferred protection against rinderpest.

No. V Cow.—On the 19th, the sixth day after inoculation with blood, the animal appeared dull, coat staring, and the following day shivering supervened. The temperature on the 21st evening attained its highest, *viz.*, 105.6°F . and then commenced to fall, afterwards running within normal limits.

No. VI Bull.—The temperature of this animal never exceeded the normal limits after inoculation with blood on the 14th June, and no symptom was noticed until 5 P.M. on June 27th, and then only a little mucus and blood was passed with the dung, followed by a few drops of blood later, the animal was never off its feed.

At the time of the inoculation with blood on the 14th June, Buffalo No. XV was also injected with 10 c. cm. of rinderpest blood to act as a control experiment; but, as will be seen, this animal only passed through a slight attack of rinderpest, and therefore the experiment proves nothing.

23. On June 10th (A.M.) a second series of animals (Cows VII, VIII, IX and X) were injected with 10 c. cm. of bile, taken from a

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DR. LINGARD'S REPORT.	<p>rinderpest Bull, near Tanda, at 7 P.M. on June 1st, 1897, and therefore utilised about 207 hours after collection or <i>post-mortem</i>. No rise of temperature was recorded in any of the four animals during the next ten days ; so, on the morning of the 21st June, each animal was injected with blood in order to prove whether any protective influence had been conferred by the previous injected bile.</p>
	<p>No. VII received 10 c. cm. of blood taken from the jugular vein of Bull No. XI ; No. VIII, a like quantity, whilst Nos. IX and X only received 0.2 c. cm. of blood from the same animal, mixed with physiological salt solution.</p>
	<p>The following are the principal symptoms noted in each of the four cases :—</p>
	<p><i>No. VII.</i>—Passed through a slight attack of rinderpest, but the only points noted were : a swelling the size of a cricket ball at seat of inoculation, hot but not tender, shivering on the 24th and 25th and later, dung watery with mucus and a trace of blood ; the temperature during the next 14 days scarcely exceeding normal limits. On the 27th fluctuation was felt at the seat of inoculation, and on the 29th, a small white coagulum escaped from the wound, which quickly healed.</p>
	<p><i>No. VIII.</i>—Temperature was never raised above normal limits during next 14 days, although there was a swelling as large as a man's fist at the seat of inoculation, hard and hot, but not tender on manipulation. No diarrhoea or symptoms of rinderpest were observed.</p>
	<p><i>No. IX.</i>—This animal and No. X received only $\frac{1}{50}$th amount of rinderpest blood injected subcutaneously into Nos. VII and VIII ; nevertheless, No. IX after 24 hours presented at the seat of inoculation a swelling 3 inches in diameter, hard, hot and tender, which increased on the following day to a ball 4 inches in diameter. For six days after inoculation the temperature did not rise, but on the seventh day, <i>vis.</i>, 27th June, it registered 104.4°F. and continued high until the evening of the 2nd July, when it attained a maximum of 108.5°F. It was only during the period the temperature was exalted that the animal appeared dull and left off feeding. On the morning of the 4th July, the thermometer registered 99.5°F., a difference of 9°F.</p>
	<p>This animal was very ill, suffered from hyper-pyrexia, but the symptoms of rinderpest were not marked.</p>
	<p><i>No. X.</i>—Presented a hard, hot and tender swelling, 5 inches in diameter, at the seat of inoculation ; the tenderness gradually disappeared a few days later. The temperature never exceeded normal limits during the next 14 days, and no symptoms of rinderpest presented themselves.</p>
<p>The control Bull No. XIX, inoculated with rinderpest blood, taken from the jugular vein of No. XI, passed through a very slight attack</p>	

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of rinderpest, but did not succumb to the disease. Consequently, although the Cows VII and IX had slight attacks of the disease, animals VIII and X presented no symptoms of rinderpest.

24. The experimental researches commenced at this Laboratory by Professor Koch on June 4th, 1897, were undertaken with a desire to demonstrate his methods to the gentlemen assembled for that purpose, and at the same time to ascertain whether the means he discovered for immunising cattle against attacks of rinderpest in South Africa by the subcutaneous injection of bile and other body fluids, derived from such diseased animals, would prove as efficacious in protecting Indian cattle.

25. It will be as well first to consider what results we should have expected, if the Muktesar experiments coincided with those made in South Africa.

Animals inoculated with Rinderpest Blood.

The majority, 90 per cent. of animals inoculated with rinderpest blood, should have shown an abrupt rise in temperature on the third to the fifth day after inoculation, followed by the usual severe symptoms, *viz.*, purging, dysentery, etc., death taking place on the seventh, but not later than the eighth, day of the disease. A certain percentage, about 10, after passing through a serious attack of the malady, should have recovered.

Animals inoculated with Rinderpest Bile.

All the cattle subjected to the injections of bile obtained from rinderpest animals should have presented, merely a hard, somewhat prominent and painful swelling, of the size of a man's fist, perhaps slight lameness for a few days, in some cases, but which would gradually disappear in the course of a couple of weeks, provided, however, that the bile was not in a state of decomposition, as is not uncommon when an animal suffers from rinderpest. During this period there should have been little or no constitutional disturbance.

Bile-injected animals afterwards proved with Rinderpest Blood.

After a period of ten days the bile-injected animals should be subjected to inoculation with a varying amount, generally 10 c.cm. each, of virulent rinderpest blood, in order to ascertain whether any protection had been conferred upon them individually. If this has been the case, during the above period no untoward symptoms would have been observed on examination of the animals, and their temperatures would have remained within normal limits, feeding, etc., as in health.

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But completely otherwise would have been the condition of the healthy animals inoculated with a portion of the same blood as that used for proving the bile ones. The ordinary symptoms of rinderpest should have supervened and death followed in the majority of cases on the seventh or eighth day of the disease.

26. Now let us see what course the disease followed in the animals inoculated with rinderpest at Muktesar.

Nos. I and II were inoculated by Professor Koch with defibrinated blood from Tanda. No. I—temperature rose on the fourth day, and later severe symptoms set in with loss of appetite, dulness, purging and dysentery; and this animal succumbed to a typical attack of virulent rinderpest on the seventh day of the disease.

No. II.—The temperature rose as in the case of No. I on the fourth day, and later the animal presented all the well-marked symptoms of the disease; but instead of death occurring on the seventh or eighth day, it did not take place until the thirteenth day of the disease. So that instead of the animal dying from rinderpest it probably succumbed to a secondary infection.

On the fifth day of the disease, when the temperature was high and the symptoms of rinderpest well marked, blood was taken from the jugular vein of No. I and the usual quantity was injected into Nos. XI and XII. These animals passed through fairly smart attacks, but in both instances a normal temperature was recorded on the seventh day of the disease and the animals made an uninterrupted recovery.

On the 14th June blood was taken from No. I (*post-mortem*), and two animals were inoculated, *viz.*, Cow No. V and Bull No. VI. These had been previously injected with bile from Tanda. The effects of these inoculations were that the cow suffered from a comparatively slight attack of rinderpest from which she recovered in a few days, while the bull showed no symptoms whatsoever. The unprotected control animal inoculated with blood from the same source, which should have succumbed, or, at all events, had a very severe attack of the disease, only had a slight illness, no symptoms being manifest until the eighth day after inoculation and then only lasting 48 hours.

The other unprotected animals inoculated were No. XIX from blood taken from No. XI. In this case, if the disease was present, it must have been of the slightest character. No. XXII, inoculated with blood from No. XV, only passed through a mild attack of rinderpest, but although the temperature recorded was very high, the symptoms were poorly marked.

From the above it will readily be observed how the virulent rinderpest blood, which at first produced death in the usual time, and accompanied by well-marked symptoms of the disease, when inoculated into other animals, gradually lost its power of re-producing rinderpest, and finally became so attenuated that it almost failed to produce any symptoms at all.

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27. The following table shows in tabular form the different animals inoculated with *ante* and *post-mortem* blood derived from Bull No. I, which was injected with rinderpest material, 73 hours old, from Fyzabad District:—

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Blood obtained from Tanda.

No. I.

Typical Rinderpest.

Very severe.

Ante-mortem blood *Post-mortem* blood.

drawn from Vena jugularis. drawn from Heart.

Smart attack. XI.	Smart attack. XII.	Slight attack. V.	Slight attack. VI.	Slight attack. XV.
No typical symptoms. XIX.				Very mild. XXII.

28. From information kindly communicated by Professor Koch concerning the course of rinderpest in South Africa, it appears that the disease, both when acquired spontaneously and after inoculation, runs its course in a definite number of days, *viz.*, 7 to 8. In the event of an animal dying at a later date than the above, death is frequently not due to true rinderpest, but to a secondary infection, frequently caused by a distinct species of micro-organism (*Streptococcus*).

In South Africa the temperature of the inoculated animal, which generally remained up to the fourth or fifth day within normal limits, rose abruptly to 104°F. or over, remaining high up to the evening of the sixth day of the disease, when it rapidly declined until death supervened.

Of the seven animals inoculated at Muktesar with rinderpest blood, two only died, those being Bullocks, No. I and II, which were inoculated with blood directly brought from the case at a village near Tanda. The other five recovered after attacks of rinderpest varying in intensity.

29. To account for the severe type of disease found in South Africa, we must remember that the outbreak in that country was a new malady, affecting the animals of a country which had not been previously attacked by a like epidemic in the memory of man, and therefore spreading over 'Virgin Soil,' as in the case of measles in 1874 introduced from Sydney, when one-fourth of the inhabitants of the Fiji group were carried off. Numerous like instances with regard to other diseases, *e.g.*, small-pox, syphilis, etc., might also be added.

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The symptoms observed as a consequence at the Cape were of a far severer type and the mortality greater (90 per cent.) than that generally observed in the plains of India. In the Himálayas, however, the mortality amongst cattle suffering from rinderpest reaches 95 per cent., or even 98 per cent. in exceptional epidemics.

In the plains of India, the mortality from rinderpest may frequently be observed to be very slight, varying from 25 to 10 per cent. Probably several causes may be put forward to account for this attenuated form of the disease, but at the same time it must not be forgotten that although rinderpest may go smouldering on, attacking only very few of the cattle of a certain district, and those with a mild form of the disease, nevertheless, without any warning, a most virulent form of rinderpest may break out and be accompanied by a high mortality.

30. *Breed.*—May perhaps in some instances bring about a certain amount of immunity against cattle plague, for it is well known that Pasteur proved Algerian sheep immune against anthrax, although French sheep readily succumbed after inoculation with the same virus.

31. *Immunity.*—In India and the East rinderpest has been existant probably for hundreds of years, and it is extremely difficult to ascertain in such a vast extent of territory, what immunising effect may have been acquired by some of the cattle of this country. It is probable, however, that in some districts the cattle have received a certain amount of protection against rinderpest through their progenitors, but up to the present this has been impossible to estimate. At the same time, young cattle frequently succumb to a virulent form of the disease even when older cattle in the same district are little affected by the epidemic, and when these latter have not been known to suffer from the malady even in a mild form. It is well known, however, that an animal may be attacked with so slight a form of rinderpest that it may even be overlooked by the initiated in this disease.

Influence of Heat on the virus of Rinderpest.

32. The most potent cause of the attenuation of rinderpest amongst the plain cattle of India, we should imagine, is due to the influence of the higher temperature to which the virus is exposed during the hot season. Observers, long before Professor Koch studied rinderpest, have pointed out that the virus of this disease may be destroyed by exposure, for a short time, to a temperature far below that found in the direct rays of the sun during the hot season on an exposed plain in India; but Professor Koch has lately shown in South Africa that the virulent blood from a case of rinderpest may completely lose its virulence after being exposed to a temperature of 87·8° F. for four hours. From this it would appear that if a *post-mortem* on a rinderpest animal were conducted in the open, and the ground besmeared with blood, nevertheless after a period of four hours (during three-fourths of the year) no infection would follow, if animals were kept off the infected area until the above time had elapsed.

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*Attenuation of the Muktesar virus.*DR.
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33. In the present state of our knowledge, it is impossible for us to give a satisfactory explanation of the causes which led to so rapid an attenuation of the rinderpest virus, as that which occurred when animals were inoculated with material brought up to the hills (7,500 feet elevation) from the plains. The animal, nine years of age, first to be inoculated, was bred and born in the plains, but of late years had been kept in the mountains. This animal died of a typical well-marked rinderpest in exactly the same time as was found in South Africa. But in the later inoculations the disease proved abortive, both in plain and hill cattle. We recognise, however, the fact that the period of the year (June), when these experiments were undertaken, was the very worst possible one, for obtaining virulent rinderpest in the plains.

Those who have observed the changes in the virulences of rinderpest during the different seasons of the year, recognise that the virus becomes least potent in its action, at the end of a hot season, when the disease simply smoulders through the cattle of the low country, causing a mortality of not more than 5 per cent.

We must not forget also that the months of May and June 1897 were the hottest part of an exceptionally torrid season. In addition, it is a well recognised fact that in every severe epidemic, whether attacking human beings or animals, the mortality is always greater at the commencement of an outbreak of disease, than towards its termination, when cases generally recover without any treatment.

Further, Koch has made a special point of the fact that in order to transmit rinderpest successfully, blood should be taken from the infected animal during the earlier stages of the malady, when it does not contain any septic organisms, but simply the contagium of the disease. The greatest difficulty, however, was experienced by us in finding any cases of rinderpest at all, in the Fyzabad District, so that the only virus obtainable for conducting investigations at Muktesar, had to be collected from the heart of an animal which had succumbed to rinderpest more than half-an-hour, before the autopsy was made. To one or more of the above causes, therefore, must be ascribed the cause of the attenuation of the rinderpest virus, which will have to be guarded against in future experiments.

Objections to the method.

34. (i) The greatest difficulty is the fact that the bile does not keep at ordinary temperatures of the air, and that according to Koch only green biles can be used for protecting cattle. But green biles are only obtained rarely, the most frequent proportion being one in seven.

(ii) In this country where the cattle are small, 150 c. cm. (5·27 ozs.) of bile is all that one can hope to obtain from an animal, whereas in South Africa Professor Koch stated the amount averaged 500 c. cm., but that it was not at all unusual in large cattle for him

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to obtain 1,000 c. cm., equivalent to about 35 ounces. As in Africa only 50 animals can on the average be inoculated from the bile of an animal (500 c. cm.), it follows that one rinderpest animal is required under the best conditions to inoculate seven animals. In this country (India), therefore, where 150 c. cm. of gall is the highest amount obtainable from one case, one rinderpest animal would only prove sufficient to inject 2·14 head of cattle.

(iii) It would be an easy matter to follow out this method of protection in districts where rinderpest already exists, but in case animals have to be protected in parts of the country where no disease is then present, virulent material would have to be transported to the scene of inoculation and animals inoculated, in order to provide bile in sufficient quantity. This is a serious objection to the method, but as a considerable number of investigations must be carried out before this system can come into general use, some modification in method may probably be discovered.

35. On the other hand, a very good instance of the great utility of the bile method is taken from Koch's experiments on a farm 'Susanna' on the Free State Border—

"Rinderpest broke out on the 20th January on the farm of Mrs. Lisching. In this case, as in so many others, the introduction of the epizootic was due to the intercourse of the Kaffirs with other natives belonging to infected farms. On the 2nd February 1897, 180 head of cattle were much infected; 29 cattle which appeared sound and had been kept separate were injected with bile which was taken from an animal that had died the day before of rinderpest, after a sickness of six days. This bile had a dark green colour, was almost clear, and had the same smell as bile from a sound freshly-killed animal."

"All the animals injected with bile showed more or less prominent swellings at the point of injection, and, as a consequence, some were lame for a few days. These swellings went down in the second week and soon disappeared entirely. Not one of the animals had an abscess as a consequence of the inoculation. On the sixth day after the inoculation, four animals fell sick with symptoms of rinderpest. Of these, three succumbed, and one which had the disease in a less virulent form, recovered."

"Taking into account the time of incubation, it appears very probable that these animals were infected before the inoculation, even on the very day of the inoculation the animals might have been infected, because for the purpose of injection they were thrown on the floor of a Kraal in which those cattle suffering from rinderpest were kept every night. The floor of the Kraal was covered with rinderpest matter, and being moist, it was impossible to avoid soiling them where they were thrown."

"The total result for this group is—even if I consider the latter doubtful case of rinderpest—that out of 29 animals, in spite of the extraordinarily unfavourable circumstances, 25 were preserved by a single injection. To convince myself, however, beyond a doubt that the animals were actually made absolutely immune, I took on the

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15th February four animals indiscriminately out of this group and injected them with virulent rinderpest blood. The injection had not the slightest effect upon the animals, whereas two other cattle which were kept segregated in the experimental station fell sick and died with severe symptoms of rinderpest, after having received an injection of the same virus."

"The results I obtained in this way with the bile injection appear satisfactory. It proves, moreover, at the same time, that the bile injection has the same beneficial effect at rinderpest farms, where infection is a matter of natural consequence, as at experimental stations where the immunised animals may be re-tested by artificial injection with rinderpest blood."

36. I have no doubt personally that Professor Koch's system of protection, by the use of Rinderpest Bile, as worked out by him in South Africa, really possesses the virtues he ascribes to it under certain conditions in that country, where the disease is of such a virulent character. But even the above experiments have not been entirely without disaster, for, some cattle injected with bile have shown an enormous mortality, and it is reported that no clean herd has yet been inoculated with bile in which rinderpest did not follow. What the outcome will be in this country cannot at present be foretold, as investigation will have to be undertaken with a view to determine many points now obscure, with regard to the different degrees of virulence found in rinderpest outbreaks.

37. There are, however, outbreaks of exceptional virulence in the Himálayas, and much less frequently such occur on the plains of India, more especially during the cold weather. With bile collected from such epidemics in the future, we may be able to obtain similar results to those which were demonstrated in the African outbreaks. But it must be clearly understood that cattle herded together at the commencement of an outbreak, cannot all be protected, even if injected with rinderpest bile, immediately the first case of disease is discovered amongst them, for, a varying percentage of animals must inevitably have contracted the disease previous to the use of the protective agent.

38. The experiments commenced at Muktesar, under the supervision of Professor Koch to ascertain the value of rinderpest bile as a protective agent against that disease in India, have up to the present proved very little, as the method has not been practically tested owing to the gradual diminution in virulence of the rinderpest blood used. Before the animals, which have been injected with the protective agent, can be proved and declared immune, it will be necessary to again procure blood from animals suffering from rinderpest in a virulent form, and subject them to inoculation with it.

39. On several occasions I have pointed out to Government the extreme importance of pursuing my investigations with regard to rinderpest, with material obtained from the most virulent source; otherwise much time would be lost and expense incurred. The result being a protective agent only powerful enough to protect

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animals from a very mild form of the disease but which would render them susceptible to attacks of virulent rinderpest when exposure occurred at a later date.

40. It is unnecessary for me to go into details with regard to the protective inoculation with serum, as this, in its present form, is somewhat unwieldy and difficult of carrying out, except in experimental form.

41. Another modification of Koch's method is one which promises much more elaborate results and which can be applied with very little extra trouble. I refer to the admixture of rinderpest blood to bile in the proportion of 1 part of the former to 9 of the latter. Researches will have to be carried out in order to test several of these side issues, for, probably we may find that *ordinary* bile, if mixed with virulent rinderpest blood, may serve the same purpose, and thus we should be able to do away with one of the great difficulties of the method, *viz.*, the requirement and attendant difficulty of obtaining large quantities of rinderpest gall. In one experiment with rinderpest bile and blood tried at this Laboratory, success has attended the attempt, but it would be premature as yet to pronounce the method a success, as during further researches some unforeseen difficulties might arise.

42. If the bile method proves a success in this country when further trials with virulent material have been made, Government would be saved great expense and would probably run very little risk in the first instance by allowing their bullocks to undergo the protective inoculation. Again, it will be a great stand-bye, if during a campaign rinderpest should make its appearance on the line of communication (as was the case during the Chitral Campaign), the protective injection of bile could be had resort to, for the whole process would not incapacitate the animals for more than two weeks. The protected ones would be unlikely to again contract the disease, and they would be worth more than double their original value.

43. I would suggest, that in view of the recognised difference in the susceptibility to rinderpest exhibited by hill cattle and those of the plains, that two distinct sets of experiments be carried on concurrently, but separately, with a view to testing the efficacy of the rinderpest bile protective method and the period during which it renders the animals immune. The former could be undertaken at the Bacteriological Laboratory, Muktesar, while the latter would have to be arranged for on the plains, for it can easily be understood that by moving either set of animals from their accustomed habitat to a colder or warmer climate, as the case may be, the results of the experiments may and probably would be materially altered or entirely vitiated.

44. Whatever experiments are now initiated must be undertaken with the greatest difficulty and uncertainty owing to the want of proper accommodation for the experimental animals. Four of the plains cattle have already succumbed to *Enteritis* owing to the altered conditions of food, temperature, etc., to which they have been sub-

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jected during a recent period of rain lasting some days, when 20·43 inches fell.

45. A further report will of course be submitted when the experiments have reached a more advanced stage, and something definite has been arrived at with regard to the bile method.

46. During a long conversation I had with Professor Koch concerning rinderpest, we fully discussed the different questions of interest connected with the study of this disease. The Professor indicated the lines which, in future work, would be most likely to lead to the advancement of our knowledge and produce results which may prove of the greatest benefit to Government with regard to the preparation of a serum of high protective power against rinderpest. The serum at present in use has been shown to produce a protective effect, when injected subcutaneously into healthy cattle, in quantities of not less than 100 c. cm. at one time. But future investigations must, to be of general utility, produce one possessing a much greater immunising power, so that 10 c. cm. will be able to produce a like or greater effect on the animal than the quantity now used. For the preparation of such a blood serum Professor Koch points out that a centrifugal machine must be used—each cup capable of holding at least 500 c. cm. ($\frac{1}{2}$ litre)—with a velocity of 4 to 5,000 revolutions a minute. For this purpose an engine of several horse-power would be required, worked by means of steam, gas, oil, or electric power. Several of these centrifugal machines are now being used in, and within a few miles of Berlin for the manufacture of diphtheritic anti-toxin and other serums, and therefore it would be advisable, the Professor points out, to wait until an opportunity offers for thoroughly examining the machinery and becoming acquainted with its working, etc., before asking Government to obtain one for the Laboratory. However, later it will be necessary to get such a machine capable of being worked by mechanical means, for it would be impossible to obtain one capable of attaining the required velocity which could be maintained by manual labour continuously for four to five hours at a time, as would have to be done on each occasion when used.

47. Again Professor Koch remarked with regard to a probable modification of serum, "Should the necessity arise to employ serum in a preserved state, there will be no other way but to dry it in the 'vacuum apparatus,' a treatment which gave most satisfactory results with other kinds of serum." Consequently, it may also be necessary to provide the Laboratory with such a vacuum apparatus in the future.

A complete set of the charts (48 in number) recording the Temperature, etc., of the above cases was submitted with the manuscript report.

3. Veterinary-Captain Pease, Principal, Lahore Veterinary School, joined the party from the commencement, accompanying Professor Koch and Dr. Lingard to Oudh, where Rinderpest was discovered. He has entered very fully into the question, and his report is produced *in extenso* :—

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In accordance with your instructions, I placed myself in direct communication with Professor Lingard, and acting on his instructions, I proceeded to join the party, consisting of Professors Koch, Pfeiffer, and Lingard at Lucknow, arriving on the morning of the 29th May 1897.

2. Information having been received that there were cases of Rinderpest in the district near Lucknow, we endeavoured to find some, but without success. Telegrams had been sent to Barabanki, Partabgarh, and Fyzabad. The outbreak at Barabanki, however, had, it appeared, ceased a day or two before our arrival; we then, in consultation with the district authorities of Fyzabad, proceeded to that station with a view of visiting Akhbarpur, where the disease had been reported to be prevalent.

3. The district authorities gave us every possible assistance, and we proceeded to Akhbarpur on the 31st May 1897, where we found a Veterinary Assistant. There were no cases of the disease to be found in any of the villages round Akhbarpur, but the Veterinary Assistant informed us of some disease in the villages near Tanda, a Tehsil some 12 miles distant. Thither we proceeded on the 1st of June, and having sent the Veterinary Assistant to ascertain, with certainty, where cases could be found, we proceeded to Rajipur, a village some 6 miles from Tanda, the same evening, and there saw three cases of Rinderpest. We made one *post-mortem* examination of a bull which had recently died, and found the typical lesions of Indian rinderpest present in the pylorus cæcum, colon, and small intestine. There was, however, no mouth eruption, nor inflammation of the mouth.

4. The symptoms in the living animals found suffering from the disease were, fever, discharge from the eyes, mouth, and nose, and diarrhoea. From the observations made here on these animals, Professor Koch concluded that Indian rinderpest is identical, in its nature, with that which he saw in South Africa. Flasks of blood from the heart and about 200 c. cm. of gall were collected from the dead animal. The blood was collected for the purpose of inoculating animals at the Imperial Bacteriological Laboratory at Muktesar, in order to produce the material necessary for carrying out the demonstration of the system of protection there. The next morning other villages, 6 or 7 miles from Tanda, were visited by Professor Koch, and nasal and mouth slime and dejecta were collected for experimental purposes. On the same day, we returned to Akhbarpur and took train for Kathgodam, *en route* to the Laboratory.

5. *Professor Koch's method of conferring immunity.*—Professor Koch's method of conferring immunity may be best given in his own words:—

6. *Method with pure bile from Rinderpest animals.*—One is able to render immune healthy cattle with the bile of such as have succumbed to rinderpest. In this case a single hypodermic injection of 10 c. cm. is sufficient. This immunity sets in on the

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tenth day at latest, and is to such a degree that even four weeks afterwards 40 c. cm. of virulent rinderpest blood could be injected without any injurious effect. I therefore conclude that the immunity produced in such a manner is an "active" one, or confers more or less permanent immunity.

7. Of the injection the local result is merely a somewhat painful swelling of the size of a man's fist, which disappears in the course of a few weeks, provided, however, that the bile is not in a state of decomposition, as is not uncommonly the case when an animal suffers from rinderpest. In such circumstances, an abscess may form at the seat of the inoculation, which, however, does not seem to be detrimental to the process of immunisation.

8. *Other modes of proceeding with bile.*—Regarding immunisation from rinderpest, Professor Koch has undertaken many experiments for the purpose of ascertaining the best manner in which the bile may be employed, and to investigate the nature of the remarkable process by which immunisation is brought about. First, a control experiment was made with the bile of a sound animal, and the result was that such bile had no immunising effect whatever. It was also found that bile taken from a rinderpest animal, which had been killed on the third day of the disease, that is, three days after the rise of temperature, which is the first symptom of the disease, had occurred, has no immunising effect whatever, and did not protect the injected animal against the disease. Even the bile from animals, which survived the attack of rinderpest proper, but were suffering from secondary disease, and died from such causes, was found to be of very doubtful or of no protective value. It may be here remarked that typical rinderpest runs its course in 7 to 8 days at longest, and that in cases lasting longer than this period after the first rise of temperature, the true action of the rinderpest virus ceases on the seventh or eighth day, and that after this the animal is suffering from the effects of such action only. These long cases, therefore, do not produce gall suitable for protective inoculation. This is very important. For theoretical reasons, experiments by mixing larger and smaller quantities of virulent rinderpest blood with the rinderpest bile, were made, and the important result obtained thereby that the bile is able to make a considerable quantity of rinderpest blood innocuous on inoculation into healthy animals, provided that the two liquids are properly mixed. That is to say, that we may inoculate a quantity of virulent rinderpest blood into a healthy animal, a dose in fact some thousandths of which would be sufficient to produce virulent rinderpest in it, with no harmful effect, provided we properly mix it with a certain quantity of rinderpest bile. In one case, 5 c. cm. of bile mixed with 5 c. cm. of virulent rinderpest blood were injected into an animal, which became immunised by this process. It appears, moreover, that the admixture of rinderpest blood with rinderpest bile even increases the immunising qualities of the bile, *i.e.* bile taken from animals at the beginning which, as we have seen above, is not of itself endowed with any immunising power, may be transformed in this way into an effective medium, and that even the bile of sound animals might

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be used by such a process for the same purpose. Experiments in connection with this hypothesis are not ended as yet, and the matter is at present not definitely decided. Should these experiments give a good result, it will then be an easy matter to prepare, at any time, large quantities of highly immunising and uniformly acting protective medium. In practice, these experiments are so far of importance that they prove that contamination of the bile used for the protective inoculation with blood need, by no means, be scrupulously avoided. The results of the above experiments are anxiously awaited as the importance of this question is extreme from a practical point of view.

9. *Immunity produced by serum.*—The blood serum of cattle which have recovered from rinderpest, has a certain immunising effect upon healthy cattle when inoculated with it. Its protective properties, however, are not very great for 100 c. cm. of such serum are required to protect an animal against an inoculation with a small dose of rinderpest blood. This immunity is merely a "passive" one, and will only last for a short period. For protective inoculation on a large scale such serum is not applicable, but Koch succeeded in immunising in a fortnight several animals by means of a mixture of serum and virulent rinderpest blood, to such a degree that they were enabled to withstand an injection of 20 c. cm. (about 300 drops) of rinderpest blood, a ten thousandth part of which is a fatal dose. From this fact he judges that the immunity of these animals is of a much higher degree, and he believes that it is an active immunity equal to that of a beast which has contracted rinderpest and has then recovered.

10. It is particularly important to know that only 20 c. cm. of such serum are required to immunise an animal.

11. From the above experiments, Koch is led to believe that rinderpest can be eradicated with but little difficulty and within a comparatively short time by putting these methods into practice.

12. In infected parts of the country, nearly every case of rinderpest supplies a greater or lesser quantity of vaccine for those animals which are still healthy, and he is sure that thousands of cattle may be saved daily by its application.

13. Methods demonstrated at the Laboratory. The method of protection by the inoculation of cattle with simple rinderpest bile is the one which Professor Koch demonstrated to us in India; unfortunately, owing to various circumstances, he was unable to spare the time to go through all his methods, as his time was too short, only one variation was made in the inoculation, and that was the admixture of virulent rinderpest blood to the rinderpest bile. He carefully explained others to me, and Dr. Lingard will doubtless verify and continue all the experiments as opportunity occurs.

14. *What proof necessary as to the efficacy of the method.*—The only proof which is necessary as to the efficacy or otherwise of this method is, to take a number of healthy animals susceptible to the disease and to inject each of them with 10 c. cm. of bile of suitable quality from an animal affected with rinderpest, and after keeping the animals carefully isolated for ten days (the period which

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must elapse before immunity is complete) to inject a very large quantity of virulent rinderpest blood (10, 20, or even 40 c. cm.) subcutaneously into them, and at the same time to inoculate one or two other unprotected animals, as a control, with a similar dose of the virulent blood. What must then happen is, that the bile-injected animals must not contract rinderpest, whilst the non-protected or control animals must take the disease and die or at least become very ill and exhibit diagnostic symptoms of the disease. This will prove that the bile-injected animals are immune from the disease. The control animals are, of course, used to show that the rinderpest blood with which the bile-injected animals have been inoculated, is virulent and capable of producing severe fatal rinderpest in unprotected animals. Failure in any of these points then will render the test negative or doubtful. If the bile-injected animals die, it will be negative, if the control animals do not take severe rinderpest it will be doubtful.

15. *What is necessary for the demonstration.*—In order to carry out an experiment of the immunising properties of bile, then what is necessary is first to produce virulent rinderpest in some animals; secondly, to take the bile at the proper time and in suitable condition and to inoculate subcutaneously the animals it is desired to protect with 10 c. cm. of the bile; thirdly, ten days after the inoculation with the bile, to submit the animals which have been subjected to the bile inoculation to a test inoculation with a very large dose of the virulent material; fourthly, to inoculate at the same time, and with a similar dose of the same virulent material, a couple of susceptible and unprotected animals to act as a control to the experiment; and fifthly, to observe that in the bile injected animals no rinderpest occurs, whilst in the non-protected controls rinderpest with its diagnostic symptoms occurs.

16. *Method of infecting healthy animals with virulent disease.*—It is obvious that in carrying out these experiments, it is first very necessary to have some certain standard method of producing the virulent disease amongst healthy animals in order to provide the material required for protective inoculation, as well as virulent virus with which to test animals. The method which has been in vogue in Russia, for a very long time, is feeding with virulent dejecta and smearing the nostrils with slime from animals suffering from the disease. Professor Koch states that he has been able to demonstrate that the ordinary methods of infection hitherto employed are exceedingly ineffective, and that a large proportion of those cattle that it was tried to infect by means of slime from diseased animals smeared on the mucous membrane, etc., failed to contract the disease.

17. The method of infection, which he advocates, is the injection of defibrinated blood into the dewlap, and in this manner a very severe form of the disease, which has an incubation period of three to five days, is produced, the animals succumbing and exhibiting all the *post-mortem* appearances of rinderpest. By this method every experiment has been positive in South Africa.

18. *Best time for taking the blood for incubation.*—The blood for this purpose is best taken at an early stage of the disease,

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when the blood of the affected animal will generally be free from putrefactive or other germs and contain only the virus of rinderpest. It may well be taken on the third or fourth day after the first rise of temperature. The virulence becomes less at the end of the disease, as has long been known.

19. Method of collecting blood from the living animals.—

In order to collect virulent blood from the living animal, it is necessary to cast and secure the beast in the ordinary way. A round block of wood is placed under the neck in a suitable position to raise it at the part where the operation is to be performed. The spot selected over the jugular vein is determined by bending back the ear and noting where the tip rests. The hair is now closely cut or shaved over the seat where the incision is to be made and the part carefully cleansed with perchloride solution. The vein being now raised, an incision two or three inches long is made with a sterilised knife through the skin on to the jugular vein, freely exposing it. A sterilised trocar and canula is now pushed into the jugular, and the trocar being removed, the blood is allowed to flow into sterilised vessels. The wound is now carefully sutured, and the animal after the application of antiseptic to the part is allowed to rise.

20. Blood should be defibrinated.—The blood is now defibrinated either by beating it slowly with a clean wire whisk, or by shaking for a considerable time in test tubes or flasks. It is necessary to remember not to whirl the whisk round, but to beat the blood gently with it. The defibrinated blood is now ready for use. But previous to use, it should be strained. If the blood has been collected aseptically into sterile vessels and is kept in ice or very cool, it will remain unchanged for a long time, but if not, it will, of course, putrefy owing to contamination with putrefaction germs.

21. Method of using the blood for inoculation.—The strained defibrinated blood is now poured into a sterilised syringe, and is injected subcutaneously into dewlap.

22. Quantity of blood used.—The quantity of virulent rinderpest blood which has been found capable of producing virulent rinderpest in South Africa is $\frac{1}{1,000}$ th of a c. cm., a very minute quantity. But in practice, in order to make certain of producing the disease, a very large dose, viz., 10 c. cm. or about 150 drops, is injected.

23. Local effect of the inoculation.—The local effect of the subcutaneous inoculation of rinderpest blood, taken in this way, is only the production of a small swelling which rapidly disappears, causing little trouble as a rule. If the blood be contaminated with putrefactive germs, an abscess may of course form, or other serious consequences result.

24. Method of collecting bile for immunising cattle.—The method of collecting bile from an animal dead of the disease, is as follows:—The animal lying on the left side, an incision is made on the right side, transversely to the long axis of the body completely round the posterior edge of the last rib. The flank is then cut

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back, care being taken to avoid wounding the intestines. The ribs are then lifted up by an assistant, pulling them upwards and forwards, and the gall bladder is found lying immediately beneath. A clean sterilised flask being ready, the gall bladder is grasped at its base by an assistant, in such a manner as to render it quite tense, and a small nick is now made into the most convenient part with a clean scalpel and the bile allowed to flow into the flask.

25. Amount of bile yield in Rinderpest.—The amount of bile yield from animals dead of rinderpest necessarily varies considerably according to the size of the animal. Some small animals only yield about 100 c. cm., larger ones 200 c. cm., and Professor Koch informs me that the large South African oxen sometimes gave as much as a litre ($1\frac{3}{4}$ pints). The quantity is invariably larger than in health, the fulness of the gall bladder being a prominent symptom *post-mortem* of the disease.

26. Period of the disease when gall is most suitable.—This is an important point, as it has been proved that at certain periods of the disease the gall possesses no immunising properties. It has already been proved by experiment, for instance, that gall taken on the third day after the rise of temperature is endowed of itself with no immunising properties. It has also been proved that gall taken from animals which have exceeded the period of pure rinderpest is valueless or of doubtful value. The bile is best suited for immunisation and possesses its most powerful action on the seventh or eighth day of the disease.

27. Character of suitable bile.—It has already been stated that the bile from all animals dead of rinderpest is not suitable for the purpose of conferring immunity against the disease, and it is important to be able to recognise bile which is fit for use. Bile collected on the seventh or eighth day which is of green colour, almost clear, free from offensive smell, giving off that of healthy bile only, and free from harmful bacteria is in a suitable condition. When it contains harmful bacteria, its physical and chemical properties are changed, and its smell differs from that of good bile, whilst its colour becomes yellowish or brownish.

28. Length of time which bile retains its properties.—This important point has not, so far, been definitely settled, but it is known that in ordinary conditions it soon decomposes. If it be desired to keep it for any time, it must be carefully collected aseptically and kept cool in ice. How long, however, in these circumstances it retains its immunising properties is unknown.

29. Method of making the injection.—The gall should be used as fresh as possible. The vessel containing it should be shaken, and then 10 c. cm. of it poured out into a clean syringe (Koch's pattern is most convenient) capable of containing that amount. The animal to be operated upon having been properly cast and secured, the needle is introduced into the subcutaneous connective tissue under and to the side of the sternum, and the material injected and worked into the tissue a little by rubbing with the fingers. Care is necessary to see that the point of the needle lies free in the subcutaneous tissue,

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and is not sticking into the skin or the muscular tissue lying beneath. Koch usually injected some air with the bile.

30. *Local effect of the injection.*—The effect of the local injection of the bile is the production of a considerable amount of swelling and inflammation, pain and tenderness. The swelling varies in size, but should not be less than that of a man's doubled fist. Koch lays some stress on the necessity for considerable swelling, and the seat of the injection has been purposely chosen to ensure this. The result of the injection, then, is sometimes lameness for a few days, owing to the seat of the inflammation which is produced. The swelling remains painful for a few days after which it gradually disappears going down in the second week.

31. *General symptoms produced by the injection.*—If the bile is of suitable quality and uncontaminated with putrefactive organisms, there is no general symptom produced by the injection of the bile, the temperature remaining normal and the animal apparently in its usual health and spirits.

32. *The action of bile in producing immunity.*—The manner in which the bile produces immunity is not certainly known, but its action is believed due to the irritation which it causes on inoculation. It has been above remarked that the bile in the earlier stages of the disease is incapable of conferring immunity, as is also the fact that, that from old cases has no action. It must be taken at the "acme" of the disease, when the whole system is saturated with the poison. The bile at this time is supposed to contain the greatest quantity of the most virulent virus of rinderpest, when we inoculate this bile containing the virus, as we have already seen a considerable amount of local inflammation is immediately set up and considerable inflammatory effusion takes place into the part. This prevents any absorption of the virus by the lymphatics from the seat of inoculation. The virus soon perishes at the seat of inoculation or undergoes certain changes there, and the products of its metabolism are mixed with the exuded material. This mixture is now gradually absorbed, and confers immunity in the same manner as do the anti-toxins of other diseases. This method of action is rendered the more possible for the reason that it has been experimentally proved that it is possible to mix large quantities of virulent rinderpest blood with the bile, and that the inoculation of cattle with this mixture confers immunity.

33. *Quantity of Rinderpest bile required to produce immunity.*—To ascertain what doses of rinderpest bile are required to produce immunity, Koch injected three cattle with 1, 2, and 5 c. cm. of bile each, and gave ten days later 0.2 c. cm. of rinderpest blood by subcutaneous inoculation, all these animals fell sick subsequently with severe symptoms of rinderpest, the one inoculated with 5 c. cm. recovered, and the other two died. It may, therefore, be safely concluded that an injection with less than 10 c. cm. of bile is insufficient to render cattle immune against rinderpest.

34. *Time required to produce immunity with bile.*—It must be borne in mind that the bile does not surely produce its

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immunising effect until ten days have elapsed since its injection. There is, as it were, a period of ten days' incubation of the immunity, during which, if the animal be exposed to the contagium of rinderpest, he may take the disease as easily as an animal which has not been protected. It must, therefore, be remembered that rinderpest bile does not produce immunity until these full ten days have elapsed after which only is the proof against the disorder. This is a most important point. It must not, therefore, be concluded in any set of experiments that, if there has been any possibility of mediate or immediate contagion during this incubative period, the method of immunisation is not an efficient one. What would be necessary to disprove the efficacy of the system would be, the infecting of animals after the proper period has elapsed since the immunising inoculation with suitable gall was made. Animals which have been exposed to the contagion before the protective inoculation is made, or which have been so soon afterwards, therefore may contract the disease. This exposure to contagion must naturally occur in the case of outbreaks in India, where, owing to lateness in reporting outbreaks, to communal grazing, and to general carelessness a great number of animals in a village will always have been exposed to the disease by feeding and drinking, as well as by actual and mediate contact with diseased animals. In any attempt, therefore, to adopt the system in a village, we must necessarily inoculate a number of animals which have already the virus of the disease in their system, or which may take it in during the ten days which must elapse before immunity occurs. This is the more probable when we consider that an animal does not show any symptom of rinderpest at all until from three to five days have elapsed after taking in the poison, and the only symptom then shown is rise of temperature for 48 hours or so. Such animals would, of course, have an attack of the disease in the ordinary course.

35. *Professor Koch's experiments at the Imperial Bacteriological Laboratory.*—We left Tanda on the 2nd June 1897, and proceeded as rapidly as possible to the Muktesar Laboratory, where we arrived on the evening of the 4th June. The virulent material, blood, slime, fæces, etc., had been carefully packed in ice on the journey, and most of it arrived in good condition. Most of the blood brought up was considered to be fit for use, the only danger being that cold might have destroyed the virus. No bacteria were found in the blood on microscopical examination. In the evening of the 4th June, two bullocks, numbered I and II, received subcutaneously 10 c. cm. each of the defibrinated rinderpest blood collected at Tanda, previously strained. The inoculations were made with sterilised syringes into the subcutaneous tissue under the sternum, the animals being cast and secured for this purpose. The temperature charts of these animals marked 1 and 2 will show the course of the disease in them. In bull I the rise of temperature, which is the first symptom of rinderpest, occurred on the 7th June, and the usual symptoms of virulent rinderpest, *viz.*, discharge from eyes, nose, and mouth, dulness, loss of appetite, staring coat, abdominal pain, diarrhœa, and dysentery followed in their usual

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course, the animal succumbing on the morning of the 14th, or on the seventh day of the disease. The temperature curve of this animal is a typical one of severe rinderpest and closely corresponds with those shown to me by Professor Koch and taken in South Africa. The *post-mortem* examination, conducted by Professor Koch himself, was one of typical Indian rinderpest, and confirmed his opinion that the disease here is identical in its nature with that which he met with in South Africa.

36. The temperature chart of No. II is also sent for perusal. This shows a typical rinderpest curve, the disease not so virulent in its nature. All the symptoms detailed in No. I were present, but the animal would probably have recovered had it been possible to feed him properly, as *post-mortem* examination showed that the lesions were healing. These two inoculations were made to produce bile in a proper condition for the inoculation of other animals with a view to conferring immunity. It will be seen, therefore, that No. I would be suitable, whilst No. II would not be. The bile taken from No. I was considered by Koch to be in a very good condition, and was utilised for the immunising inoculation of Nos. XIII, XIV, XVI, XVII, and XVIII.

EXPERIMENTS—GROUP II.***Production of Rinderpest.***

37. Another experiment which was made was, with a view to testing the slime and dejecta which had been collected at Tanda, as to their virulence, and for this purpose the animals Nos. III and IV plain's cows, were selected. On the 6th of June, No. III received about 10 c. cm. of the blood-stained dejecta as a drench mixed with water, and had the nostrils smeared with slime taken from a buffalo suffering from severe rinderpest. The temperature chart, sent herewith, marked 3, shows that on the 11th June, or five days after receiving the material, she was attacked by virulent rinderpest, all the symptoms of which followed, and that death occurred on the 18th or seven days after the rise of temperature.

38. No. IV, on the other hand, which received on the same day similar material taken from a bullock at Tanda had what appeared to be only a very slight attack lasting for five days, or from the 16th June to the 21st. The symptoms, however, were not well marked, and it is somewhat doubtful whether the animal really suffered from rinderpest or not, although it is believed that she did owing to the unfortunate fact that our rinderpest virus has almost completely lost its virulence; we have been unable to subject this animal to a test inoculation with virulent rinderpest blood.

EXPERIMENTS—GROUP III.

39. *Immunisation.*—Of the bile collected at Tanda, two animals, the only ones available for the purpose and numbered V and VI, received subcutaneously into the breast 10 c. cm. These animals were under my O. 590-94.

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charge. The injection was followed by the usual swelling at the seat of inoculation and the animals continued otherwise in good health.

40. *Test of efficacy of the bile injection.*—On the eighth day following the injection, Dr. Koch having been ordered by the Imperial German Government on special duty had to leave. He decided to apply the test to these animals himself before leaving. This was done by taking the blood of No. I bull dead of virulent rinderpest and injecting 10 c. cm. subcutaneously; young buffalo No. XV. unprotected received a similar dose to act as a control to the test.

Results.—The tested animals were placed in the rinderpest shed on the same day that they received the test injection of virulent blood. The result of the test was that on the 19th, or five days after the inoculation, cow No. V became sick and passed through all the phases of a mild attack of rinderpest, lasting five days, after which she recovered and is now in good health. No. VI showed no symptoms of the disease at all, continuing in good health, until the expiration of 3 weeks, so that he appeared to be immune.

41. The control animal No. XV, however, only had a very slight and short attack of the disease from which he was at no time very ill, although he had not been protected in any way, and although he received a large dose 10 c. cm. of the virulent material, he recovered.

42. *Doubtful benefit.*—It appears, therefore, from this experiment that cow No. V had no immunity conferred by the bile, or at least only a very slight amount, and at the same time that the rinderpest virus is losing its virulence.

EXPERIMENTS—GROUP III.

43. *Immunisation.*—In the meantime, more animals having become available, four animals Nos. VII, VIII, IX, and X received 10 c. cm. of the original Tanda bile, 10 days old. Tanda bile by subcutaneous inoculations in the usual manner. The bile had not apparently changed in its properties, and contained no more bacteria than before. These animals were inoculated with the bile on the 10th June, or when the bile was 10 days old. They remained in good health after the inoculation, and it was decided to test them with virulent material on the 21st of June.

44. *Test of the experiment.*—Blood was taken for this purpose from the jugular vein of case No. XI which had been infected with rinderpest from bull I for this purpose. The blood was taken from the living subject in the usual manner on the seventh day of the disease which had been severe in him up to this time. A little variation was made in the manner of testing in this case inasmuch as VII and VIII received each 10 c. cm. of virulent blood, whilst IX and X received only 0.2 c. cm. of the blood mixed with physiological salt solution.

45. *Control of the experiment.*—At the same time, a small bull No. XIX unprotected, received an inoculation of 10 c. cm. of the same blood to act as a control to the experiment.

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46. *Result of the experiment.*—This experiment is a most unsatisfactory one, but at the same time interesting and important. The four cows which had received the bile injection were placed in the rinderpest shed. Nos. VII, VIII, and X remained perfectly healthy. No. IX, on the 27th June or the sixth day following the inoculation, commenced an attack of rinderpest which proved somewhat severe, but was not very dangerous, lasting six days and being followed by perfect recovery.

47. At the same time, the control animal XIX remained healthy in appearance and had no rinderpest.

48. *What the experiment proves.*—It will be seen, therefore, in this experiment, that Nos. VII, VIII, and XIX which received 10 c. cm. of blood, remained healthy, as did also No. X which received only 0·2 c. cm., whereas No. IX which had only received 0·2 c. cm., became attacked by the disease. It is quite possible that this animal was injected from cow V which was suffering from rinderpest, the attack being at its height when these animals were introduced into the rinderpest shed. They stood in the following order :—

VII	VIII	X	IX	V	VI	XII	XIX	IV	XI	XII	XV
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This experiment, therefore, proves little with regard to the power of the bile used of conferring immunity, as at least one of the animals operated on, contracted the disease, after the time necessary for immunisation had passed.

49. It also proves very clearly that the virulent blood used for the purpose of testing the immunity conferred by the bile, had so far lost its power of producing the virulent disease when injected into an unprotected animal, for, as we have seen, our control animal although it received a very large dose of the blood taken from No. XI suffering from rinderpest, and although it was entirely unprotected, still it did not take rinderpest.

50. This also renders it probable that Nos. VII, VIII, and X have also not received any immunity from the bile injection.

51. Unfortunately, these animals cannot at present be re-tested owing to our having no virulent blood.

52. *The above experiments no proofs either way.*—The above experiments with the view of testing the immunising power of rinderpest bile are merely experimental, and cannot be taken as proving anything against Koch's method, because, in the first place, the bile was taken from an animal which, it is said, had been dead for some time, and which had been suffering from rinderpest and its effects for over ten days, and it has been kept for five days in ice, whilst, at the same time, it was yellowish and contained some bacteria. In addition to this, the test inoculation was made too soon

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in the case of the first animals V and VI, *viz.*, on the eighth day after bile inoculation, instead of the ten days laid down by Professor Koch.

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53. *Further experiments with Laboratory animals. Group V.—Rinderpest.*—So much then for the experiments regarding attempted immunisation with the bile brought from Tanda, experiments upon which, as has just been remarked, no reliance can be placed, as regards the evidence they might be considered to give regarding the efficacy or otherwise of Professor Koch's method.

54. With a view to continuing the supply of virulent material for testing purposes, Nos. XI and XII were inoculated with 10 c. cm. each of virulent rinderpest blood taken from the jugular vein of No. I on the 11th June when the disease was at its height. Both these animals went through a severe attack of the disease, with all the typical symptoms, but both of them recovered and are now in good health. This further points to loss of virulence in the rinderpest blood.

EXPERIMENTS—GROUP VI.

55. *Immunisation.*—With the bile collected from bull No. I dead of rinderpest on the 14th June on the seventh day of the disease five other animals, Nos. XIII, XIV were inoculated by Professor Koch himself on the 14th June 1897, and XVI, XVII, and XVIII by Professor Lingard on the 15th June 1897.

56. *Blood and Bile.*—The inoculation was varied in the case of No. XIII which received a dose of 9 c. cm. of rinderpest bile mixed with 1 c. cm. of virulent blood, as it is supposed that by this means the immunity conferred is more powerful and lasting. All these animals have been under observation since the inoculation, and have remained perfectly healthy.

57. It is a noteworthy fact that the injection of 1 c. cm. of rinderpest blood did not cause the disease in cow No. XIII, and this goes to prove that Professor Koch's observations on this point are correct, and leads us to hope for a simple method of procedure in the immunisation process.

58. *These cases not tested.*—It is an unfortunate circumstance that our rinderpest blood has so greatly lost its virulence as to be useless for test purposes, which necessitates the use of the most virulent material, in order to prevent errors, we have, therefore, been so far unable to submit the animals mentioned in the above group of experiment to the necessary test.

59. *Impossibility of giving a definite opinion on the method.*—In the above-mentioned groups of experiments, it will be seen that no definite proofs of the efficacy or otherwise of the method has been adduced. It is impossible, therefore, for me to give an opinion on this point. I have, however, not the slightest doubt in my own mind that the method is genuine in regard to South African cattle, judging from the experiments which Professor Koch showed me, but, whether the method will be successful in Indian cattle or not remains to be seen.

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60. *Differences in Indian and South African Rinderpest.*—Professor Koch has only dealt with the disease as it occurs in South Africa, which assumes a very virulent form, carrying off a very high percentage of the animals which it attacks (90-98 per cent.) and running its course rapidly and with great severity. It has long been known to those who take any interest in the subject, that certain contagious diseases, notably small-pox, measles, etc., when introduced into a country for the first time, the contagium having, as it were, a virgin soil to grow upon, assume a very exalted virulence, causing excessive mortality. The same is especially true of Rinderpest as may be remembered by those who were unfortunate enough to be connected with agricultural pursuits during the great outbreak in England.

61. In India, however, as in certain parts of Russia, where the disease is enzootic, the disease varies very considerably in its course and severity. We very often meet with rinderpest in what has been termed the "Benignant form." It may, indeed, be so slight as to pass unnoticed there being no symptoms but slight fever and looseness of the bowels. We have in fact similar conditions as are met with in the Steppe Cattle, which, as is well known to those who have given attention to the subject, perish from natural contagion at the rate of 30-50 per cent. and from inoculation with the natural unweakened virus in from 5-10 per cent. only.

62. *Rinderpest here resembling Steppe Disease.*—The disease which we introduced to the Laboratory for the purpose of making experiments appears to me to closely correspond with Steppe disease.

63. The material was from an outbreak of not a very virulent nature, the disease having been dragging on in the neighbourhood for some very considerable time. It was taken from a dead animal in a village where the disease was evidently losing its virulence, as was apparent from the fact of the slowness of the spread and the length of time the cases were lasting. On inoculation at the Bacteriological Laboratory two bulls I and II, we find that in No. I it produces a typical case of virulent rinderpest destroying the animal in a typical period. No. II lasted over the period of rinderpest (seven days), and would probably have recovered had it been possible to feed him properly. Blood taken from the vein of bull No. I on the 11th June, when the disease was at its height, and all the typical symptoms of rinderpest present, and the temperature high (at the most suitable period in fact), and injected into Nos. XI and XII produced typical rinderpest as will be seen from the charts of these animals sent herewith, but the disease was evidently of a far less virulent nature, as both these animals recovered and regained their usual health, after a smart attack of the disease lasting from five to seven days respectively.

64. Blood taken from No. I *post-mortem*, and inoculated as a test to Nos. V and VI previously inoculated with bile from Tanda, produced in the cow an obvious though comparatively slight attack of rinderpest from which she recovered in a few

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days. In VI the injection produced no effect at all, the animal remaining perfectly healthy. In the control animals, we find that although the animal is unprotected (see No. XV) the injection of blood from No. I produces, after seven days, very slight rinderpest, lasting practically only two days, as far as symptoms show, and from which the animal recovered.

65. Further, we find that the blood from No. XI, taken on the 21st June, on the seventh day of the disease, and inoculated into No. XIX to act as a control animal to Nos. VII, VIII, IX, and X did not produce the disease in this animal.

66. Again, blood taken from the buffalo No. XV and inoculated into XXII produced only a mild attack of the malady which showed none of the typical symptoms of rinderpest. Thus we have a decreasing scale of virulence in the material as follows:—

		Tanda Blood

		Tanda Blood			
		No. I		No. II	
		typical death.		typical death.	
XI	Mild typical recovery.	XII	Mild typical recovery.	XV	Mild typical recovery.
				V	Mild typical recovery.
XIX	Control slight recovery.			XXII	Mild, a typical recovery.
Nil or					

None of these animals, excepting V and VI, had received any form of immunising injection.

67. Here, then, we have a state of affairs closely resembling what is described by E. Semmur as occurring in Steppe cattle, and the task of ascertaining what the significance of this may be must be left to future experiments *suggested explanations of the phenomenon*. It certainly appears to me that there are only two solutions of the phenomenon of the decrease in virulence of the rinderpest virus brought with us from Tanda, and these are, *first*, that some Indian cattle, especially those of certain plain districts, possess a similar immunity against rinderpest to that possessed by Steppe cattle, or *secondly*, that the virus of the disease has a tendency to lose its virulence in certain circumstances, the exact nature of which we are unable to decide. If the first solution should prove correct as seems probable, we can easily explain the decrease observed here. If the second, the explanation can only be unsatisfactory. It is known to some of us that the immunity which Steppe cattle possess is not shared by other breeds in Russia, and that, whereas the inoculation of natural unweakened rinderpest virus in them is followed by only 5-10 per cent. of casualties, the same inoculation in other breeds of cattle causes 90-98 per cent. of deaths.

68. It is also known to us that the virulence can be considerably lessened by passing the virus through Steppe cattle, whilst we are also aware of the fact that when such attenuated virus is passed

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through other races more susceptible, the virulence increases generation by generation.

69. *Indian Rinderpest.*—My own observations and those of Thacker and others are to the effect that we meet with many outbreaks where the mortality is not greater than 30-50 per cent. But, on the other hand, we often hear of severe outbreaks in which it is 80-90 per cent. This can only be explained either by the comparative immunity of certain cattle to the disease, as is the case with Steppe cattle, or to some decrease in the virulence of the virus owing to some influence exerted on it from outside, such as partial dessication or exposure to a high temperature.

70. *Influence of heat and dryness.*—I have, judging from my own practical experience of the disease, extending over many thousands of cases, been led to the conclusion that the heat and dryness were the causes of the lack of virulence in the disease as met with in the plains as opposed to the great virulence and severity of the disease observed in the parts of the Himálayas. The observations I made showed, plains 30-50 per cent. deaths, parts of the Himálayas 90-98 per cent. deaths. We are well aware from experiments already made that a vaccine can be prepared by exposure of the virulent material to a temperature of 117° F. to 120° F. for 20 minutes. This exposure so reduces the virulence that the material can be inoculated and produce immunity without causing severe disease. These temperatures are not unfrequently met with in India in the sun, and the influence of this on the virus would, it appeared to me, sufficiently explain the low mortality in some outbreaks.

71. In some parts of the Himálayas on the contrary, where the temperature is cool, and the air moist, the disease is very severe.

72. *Indian bile less protective than the South African.*—These various points can only be settled by close observation and experiments. But there is one very important point which may arise in connection with this slight virulence. It is very possible that the bile from an animal dead of such a virulent form of the disease as has been occurring in South Africa especially in view of the experiments made by Professor Koch in regard to mixing virulent blood with the bile to increase its immunising power, may be endowed with far higher powers of conferring immunity. From theoretical reasons this seems to me not improbable. The bile appears to owe its protective power to the rinderpest virus it contains, and Koch's experiments of adding blood increase such power. It stands to reason therefore that if this be the case, the milder the virus, the less will be the immunising power than that from severe rinderpest, and we shall have, in India, to deal with an entirely new aspect of the subject.

73. *Prospects of the practical application of the method in India.*—In regard to the applicability of the method in its present form to this country, it may be said that perhaps it is at present too early to give an opinion. It may, however, be said that it is in its present form rather unwieldy and would only be applicable to certain cases in which it might be extremely useful should it prove to be efficacious.

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74. Professor Koch's experiments in the practical application of the immunisation process at the "Susanna" farm, show that it will do a considerable amount of good. He reports as follows:—Rinderpest broke out there on the 20th January 1897, I visited the farm on the 2nd February, and found the stock of 180 head already much infected. Twenty-seven animals were dead, and at least 50 showed more or less clear symptoms of rinderpest. Experiments in protective inoculation with the animals which still appeared sound were undertaken, and 18 diseased animals were injected with blood a proportion of phenol and lesser proportion of bile. Ten animals which appeared sound received the same phenol blood, and 29 cattle which also appeared sound and had been kept separate were injected with bile which was taken from an animal which has died after an illness of six days. On the sixth day after the inoculation, four animals fell sick with symptom of rinderpest, of these three succumbed, and one which had the disease in a less virulent form, recovered. There was every possibility of these animals having been infected before the inoculation, for which they were thrown on the floor of a "Kraal" in which cattle suffering from rinderpest were kept every night, and this floor was covered with rinderpest matter. Out of 29 animals, in spite of the extraordinarily unfavourable circumstances, 25 were preserved by a single injection. To prove beyond a doubt that the animals so treated were absolutely immune, Koch inoculated four of them with virulent blood, and, at the same time, two unprotected ones to act as control. The four remained well, whilst the controls died with severe symptoms of rinderpest. From the above, it will be seen that the system may be adopted with advantage even in unpromising circumstances.

75. *Inoculation of Transport animals on service.*—It seems highly probable that the method might be very useful in the event of outbreaks of rinderpest on the lines of communication. It would have the result at any rate of stopping an outbreak in a fortnight, and the inoculated animals would be proof against the disease afterwards.

76. *Inoculation of Transport animals before service.*—It would be very useful to inoculate animals intended for service in parts of the country where rinderpest is prevalent. The advantage of having protected animals on these expeditions would be enormous, as they would be able to march unscathed through a country however severely infected it might be.

77. *Inoculation of all Government cattle.*—This might in the course of time be gradually carried out; I would especially draw attention to the advantages following the protection of Government breeding bulls previous to sending them out to their districts.

78. *Inoculation during outbreaks amongst Transport cattle.*—In the case of outbreaks among transport cattle in Cantonments, the system, should it prove successful, might with great advantage be adopted. There would be material at hand from the animals already attacked, and many animals might in these circumstances be saved and protected against the disease in the future.

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79. *Inoculation during outbreaks in the districts.*—But in the case of outbreaks in the districts, it could not well, it seems to me, be utilised to any extent at present. It must, in the first place, be remembered that the immunising process takes a considerable time, nearly or rather quite ten days, and that before this time has elapsed, should the animal be exposed to the contagion, it will take the disease.

80. In outbreaks of rinderpest, therefore, in this country, where communal grazing and herding occurs, it is always doubtful whether many animals will escape exposure to the disease during an outbreak, owing to the lack of segregation, and great carelessness which prevails in the management of matters of this kind; what is likely to occur in nearly all outbreaks may be well illustrated by the following case which is reported in the *Diamond Fields Advertiser*. The disease appeared in a herd of 248 cattle, of which only one or two were observed to be sick. These were instantly removed from the herd and isolated, while the rest were inoculated. This was done on the 27th February. On the 12th March, no less than 40 had taken the disease, but the remainder were apparently doing well. Now we are pretty certain, judging from all the experiments which have been made with rinderpest bile, even when it is mixed with a considerable quantity of virulent rinderpest blood, that its inoculation into healthy cattle does not cause rinderpest. The small experience which we have so far had in this country proves this. How then are we to account for the 40 head being attacked? Simply because during the incubation period of the immunity or before the inoculation period they had been exposed to the disease and become infected. But I am afraid that it might be difficult to get the people of this country to see the matter in this light at present.

81. *Protection of healthy cattle most hopeful.*—It has already been stated in the South African enquiry that the best results are to be obtained in operating on healthy cattle. If any method of inoculation against rinderpest is to become spread over the country, it can only safely be done by feeling our ground carefully and introducing it very gradually, commencing by inoculating at various centres animals with a view to rendering them immune and also by operating to some extent on Government animals. It might be very useful to inoculate a portion of the cattle distributed as "Thakavi grant" in villages where rinderpest has been very severe, and there is danger of recrudescence owing to which the animals bought with the "Thakavi loans" perish, and the unfortunate *raiya* finds himself worse off than before.

82. *Drawbacks of the present system.*—The present system has serious drawbacks owing to which its application to the protection of healthy animals is limited. In the first place, it is necessary to have the disease carrying off animals, to supply the material, and each animal supplies only a limited quantity of the protected bile. Secondly, all the dead animals do not supply bile fit for use. The supply of bile, therefore, can only be kept up by the inoculation of animals, which would be a rather costly process; and thirdly, it appears that the bile will not keep good, retaining its properties

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for long. These are all serious questions which must be left to the proper authorities to settle.

83. *Koch's other methods more hopeful for practical application in India.*—The further experiments in regard to the use of bile from healthy animals and its admixture with virulent blood, or the possibility of using other material with which the virulent blood may be mixed and at the same time produce immunity, seem to render it very probable that the means of manufacturing a more or less artificial protective medium seem to me to promise the best results in the matter of providing large quantities of vaccine, and it is to the solution of these problems that I look forward with most hope.

84. *Possibility of teaching Veterinary Assistants the system.*—The system if it be on the lines of any laid out by Professor Koch can be easily taught to some of the more intelligent of the students with a properly equipped contagious disease hospital in Lahore, in working order; the whole of the practical technique and theory of the subject, which is fairly simple, can be thoroughly taught, if the Government decided to extend the course to three years.

85. *An important practical point definitely settled.*—I may mention that Professor Koch has confirmed the observations of Semmur and others in regard to the efficacy of drying in the destruction of the rinderpest virus. He states, "In continuation of my experiments with dried rinderpest matter, several animals were fed with the dung, flesh, and skin of the pest animals, which substances were dried for a fortnight in the shade and soaked before feeding. The animals remained perfectly sound." In accordance with these facts, the conclusion may be justified that the pest virus in its different qualities, is soon killed by dryness, and that the dry process forms one of the simplest and best ways to render rinderpest matter innocuous.

86. This has a most important bearing on the hide trade. I pointed out so long ago as 1894, that drying destroyed the rinderpest virus and that dried hides do not form a danger in the transmission of rinderpest.

87. This fact will also again bring into prominence my recommendation for the establishment of skinning enclosures outside every village, in which the *Chamárs* should be made to skin dead cattle, as a part of the village arrangements. This will limit the spread of rinderpest in a very marked manner. If the animals be skinned, as suggested in my Annual Report of last year, the sun will soon destroy the rinderpest virus. The skins should be dried in the enclosure and on no account washed in the village tank. The adoption of simple methods of this kind will go a long way to help the people and are really of very little trouble.

88. In conclusion, I have to thank Professor Lingard for his courtesy and assistance during my deputation, and for giving me opportunities of studying in the Laboratory, during my vacation.

4. Veterinary-Captain Hagger, Principal, Rajputana Veterinary School, reports as follows:—

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With reference to your endorsement No. 3841-G—869, dated 28th August 1897, I have the honour to submit the following remarks on Dr. Koch's method of inoculating cattle as a preventive against rinderpest, as witnessed by me at Muktesar in June last.

2. Dr. Koch claims to have proved that ten cubic centimetres of bile, taken from the gall bladder of a bullock that has died of rinderpest on the sixth day of the disease, will, when injected into a healthy animal, render that animal immune to the disease after the sixth day.

3. He distinctly points out that it is not a curative agent, and admits that cattle exposed to infection either just before, or within six days after the operation, are liable to suffer from the disease, but he states that those attacked after they have been inoculated, and before immunity has been given, *i.e.*, before the sixth day, suffer less in proportion to the number of days that have elapsed after the immunising agent, *viz.*, bile, has been injected, and that after the sixth day, they enjoy complete immunity.

4. The correctness of the above conclusions was amply proved by experiment at Muktesar, where six bullocks were inoculated by Dr. Koch in the manner described, and, after the lapse of six days, resisted the disease after being injected with virulent blood taken from animals that were either suffering from, or had died of, rinderpest, and I understood Dr. Koch to say that he had never known an animal treated according to his method to suffer from rinderpest provided that the process was carried out under proper antiseptic precautions.

5. Dr. Koch, reasoning on his experience as Bacteriologist, holds a theory which, however, he has not yet worked out by experiment, *viz.*, that the serum of an animal that has been rendered immune and resisted virulent blood, will protect others against rinderpest. The anti-toxin thus obtained should consist of one part of virulent blood to 99 of serum, of which mixture 20 cubic centimetres are injected.

6. With regard to the second paragraph of Inspector General's letter No. 1117—191 M., received under your endorsement above quoted, I have the honour to state that the Ajmere Veterinary School being bounded on three sides by forest preserve in which cattle are not permitted to graze, is, in my opinion, singularly well situated for carrying out experiments in connection with rinderpest, with a minimum risk of conveying contagion to cattle in the surrounding district, and, should the Inspector General, Civil Veterinary Department, desire it, and the Agent to the Governor General approve, I am prepared to take up the work as soon as the necessary material can be procured.

5. Veterinary-Captain Raymond, Superintendent, Civil Veterinary Department, Bengal, was first deputed by the Government of Bengal to Bombay, to consult Professor Koch, and after his interview expressed the following opinion :—

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"The operations as adopted by Professor Koch, appear to be perfectly simple, but in practice difficulties are likely to confront the untrained at every step: from these causes accidents are already happening in South Africa.

"The preventive treatment only confers immunity about six to eight days after inoculation: during the interval the animal may catch rinderpest.

"It happens that Cattle Plague is latent in the system for about three days before any symptom is noticed. The inoculation with preventive serum in such a case would not prevent the animal suffering or dying of the malady.

"Moreover, it is at least possible that clumsy management by the inoculator may infect a healthy animal with Cattle Plague at the very moment he is injecting the protective serum.

"There can be no doubt that in the Laboratory and in South Africa in skilled hands, Koch's methods are quite successful.

"It remains to be seen if, out here, any modifications are necessary.

"In any case it is desirable to remember that the matter has scarcely got beyond the Laboratory stage, in spite of Press notices and reports."

6. When it was decided that Professor Koch should visit Muktesar, Veterinary-Captain Raymond was again deputed to attend the demonstration: the results following his deputation, and the experiments carried out by him up to date, are contained in the following report, which it is deemed advisable to print *in extenso* :—

In answer to your No. 1537-A of 14th September, which reached this office during my absence on tour, I have the honour to report on the subject of rinderpest as follows :—

1. In paragraph 150, page 14 of my Annual Report for 1896-97, I drew attention to Dr. Koch's experiments in preventive inoculation which he was carrying out in South Africa, and I added, "If it is found to be safe in India, as at the Cape, I purpose to employ this method of experiment."

2. It will be within your recollection that as soon as it was known that Professor Koch had landed in Bombay, the Government of Bengal always solicitous to reduce the great annual losses from rinderpest, deputed me by telegram to confer with him.

3. Upon my reporting that Professor Koch was willing to demonstrate his system, the Bengal Government at once expressed its willingness to defray the expenses.

4. In the meantime, the Government of India had taken the matter into consideration, and Bengal withdrew in favour of the former, the result of the negotiations between the Imperial Bacteriologist and Professor Koch being that the demonstration took place at the Imperial Bacteriological Laboratory at Muktesar, and not in Bengal; all Principals of Veterinary Schools were directed to attend.

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VETERINARY- CAPTAIN RAYMOND'S REPORT.	5. While at Muktesar, I saw Professor Koch inoculate several animals with bile and watched the effect, which was confined to the formation of a swelling near the seat of inoculation. No symptoms of disease were shown by the animals.
	6. I did not witness any demonstration of the serum treatment.
	7. The following is an extract from my letter No. 771 V.D., dated 26th June 1897, which bears upon this subject:—
	“Professor Koch's work, though successful in the Laboratory, has still to be studied in its relations to Bengal cattle.”
	Professor Koch impressed on me that much remains to be done in this direction. If Government is willing, I can easily seek to apply the knowledge acquired.
	8. With regard to paragraph 2 of No. 11118—191 M. from the Inspector General, Civil Veterinary Department, which you forward, I have the honour to report that a few experiments have been carried out partly at Belgatchia, and partly in my own garden, and partly at Kanti. There was little danger of rinderpest spreading at the time, for scarcely any cattle came to Belgatchia for treatment, and I had immunised my own cattle. My own garden is completely enclosed.
	9. But latterly, the popularity of the Infirmary seems to have increased amongst cattle owners, and there is some risk of infection being carried. I am, therefore, glad to state that Government has under consideration a scheme which will render it possible for experiments to be carried out without any danger to other cattle.
	10. I beg to bring to notice some work which I have carried out in connection with rinderpest inoculation.
	11. In the month of May, an outbreak of rinderpest was reported from Munshigunge, and I directed my Veterinary Assistant to send me some material from a sick case for experiments. Unfortunately it arrived in such a decomposed condition that the result of an experiment on sick calves was a failure.
	12. On the 25th June, a bullock belonging to the Chitpore Municipality was admitted at Belgatchia, suffering from cattle plague and died. The <i>post-mortem</i> report is appended (Appendix I).
	13. From this animal, two calves were inoculated, but proved to be immune, and as the outbreak was sporadic, my material came to an end.
	14. But from the bile collected from the bullock, I inoculated four calves, four bulls, and three bullocks. The dose was 10 c. cm. each.
	The result went to prove that the operation was perfectly harmless. The animals had a slight swelling at the seat of inoculation, but they showed no sign of any kind of disease and fed and worked as usual.
	15. On the 31st August, I received an urgent telegram from Muzaffarpur. Upon my arrival, I found Mr. G. R. Toomey of the Kanti Indigo concern, who, whilst driving me to his place, told me that cattle plague had been raging on the estate since the 3rd August, and that he had lost 86 head of cattle. I ascertained that some 400

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or 500 head of cattle had died in the neighbouring villages. Mr. Toomey had heard that I was desirous of experimenting with rinderpest, and in the most public-spirited manner expressed his willingness to assist me, undeterred by some hostile criticisms of the method which it was my duty to send to him.

16. It should therefore be noted that Mr. G. R. Toomey is the pioneer in India in what may possibly become a very important public benefit. Besides the risk of the loss incurred by Mr. Toomey (for a new thing is always more or less risky), he has refused to recoup himself from the small sum given by Government for experiments, stating that he would rather see the money used for further work.

17. Having decided upon inoculation, the next thing was to procure suitable materials. It was obviously out of the question to kill any of the cattle owing to the religious opinions of the people. On the other hand, observations upon cases that had succumbed during various outbreaks had shown me pretty clearly that the bile was very often unsuitable in cases that had died in the usual way. Unless the bile can be removed at once, it is nearly always useless. Hence there was an element of uncertainty over the work which it was desirable to remove. There is fortunately no prejudice against killing buffaloes. I therefore recommended Mr. Toomey to procure some buffaloes. I there obtained a typical case of cattle plague wherewith to infect the buffaloes. This case (Buffalo A) showed all the symptoms in a marked degree and soon died (for *post-mortem* appearances—see Appendix II).

18. Buffalo No. 1 (see Appendix III) besides receiving material from Bullock A was also treated with material from a young calf that had died without showing all the typical symptoms of cattle plague. Four other buffaloes (Nos. 2, 3, 4, and 5) were also treated with material from Bullock A.

19. Having prepared the way for further work, I returned to Calcutta to my other duties, leaving my Assistant to report by wire when the temperatures of the buffaloes were rising. I returned to Kanti, and on the 3rd September, Buffalo No. 1 was shot (*vide* Appendix III). The bile was extracted and placed in ice. On completion of the *post-mortem* examination, I examined the bile under the microscope, moreover the colour and odour were satisfactory. In the afternoon I injected 10 c. cm. of the bile into each of 12 head of cattle, which were then branded $\overset{K}{T}$ 1-12.

20. On the 5th September, Buffaloes Nos. 2 and 3 were shot (*vide* Appendices IV and V for details). Bile was extracted from both animals, found to be good, and placed in ice. The bile from Buffalo No. 2 was used the same afternoon to inject 28 head of cattle which were branded $\overset{K}{L}$ 1-28.

21. On the 6th September, I injected 32 head of cattle with bile from Buffalo No. 3, which had been kept in ice. This batch was branded $\overset{K}{L}$ 1-XXXII.

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22. On the morning of the 7th September, Buffalo No. 4 was shot (for details of temperature, etc., *vide* Appendix VI). I extracted the bile which was good, and placed it in ice. In the afternoon, I injected 21 head of cattle, which were branded $\overset{K}{\underset{T}{1}}$ -XXI.

23. On the 9th September, Buffalo No. 5 was shot (for details of temperatures, etc., *vide* Appendix VII). From this animal, I obtained a quantity of bile, but of the remaining cattle of the herd I only inoculated 14, because some were too wild to catch and others were cows in calf. This batch was branded L K 1-XIV.

From the same animal I secured a quantity of virulent blood for testing experiments. This was placed in ice. Some of the blood and the remainder of the bile was also placed in ice and taken to Belgatchia.

24. I wish here to mention that Mr. Toomey told me that cattle plague had not been known on the estate nor in the neighbourhood for at least eight years and probably more. Mr. Toomey breeds his own cattle. This points to the probability that none of the animals on the estate had been rendered immune against cattle plague by suffering from a previous attack.

25. It was found impracticable to take the temperature of the 108 cattle that had been treated with bile, but they were all repeatedly inspected by Mr. Toomey, his Assistant, my Assistant, and myself, and I was surprised to see how little swelling was to be seen: only in two cases did it interfere with the gait of the animals. Constitutionally none of the animals appeared to suffer in the slightest degree.

26. Professor Koch states that the bile injection confers immunity not later than the tenth day.

27. In order to test the immunity of the animals after the bile treatment, 6 bullocks were selected simply because they were blind or lame—

(a) bullocks $\overset{K}{\underset{T}{2}}$ and 10 each received subcutaneously 20 c. cm. of virulent blood from Buffalo No. 5 on the 10th September, that is to say, seven days after the bile inoculation (see Appendices VIII and IX);

(b) bullock $\overset{K}{\underset{L}{15}}$ received subcutaneously 10 c. cm. of virulent blood from Buffalo No. 5 on the 12th September, that is to say, after seven days after bile inoculation (see Appendix X);

(c) bullock $\overset{K}{\underset{L}{16}}$ received 20 c. cm. at the same time, under the same circumstances (see Appendix XI);

(d) bullock $\overset{K}{\underset{L}{1}}$ (Appendix XIII) received 10 c. cm. of virulent blood from a case of Belgatchia (*vide* Appendix XII) on the 16th September, that is, eleven days after inoculation with bile.

(e) $\overset{K}{\underset{L}{2}}$ received 20 c. cm. of the same blood on the same date and under the same conditions (*vide* Appendix XIV).

All these animals proved to be immune.

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28. The dose of virulent blood used in these test cases is said by Koch to be respectively 5,000 and 10,000 times greater than a fatal dose.

29. The experiments above recorded go to show that Professor Koch's preventive treatment with bile promises to be successful in Bengal. The exact amount of success can only be determined by future experiment.

30. Here again Mr. G. R. Toomey has rendered great assistance by permitting the inoculated bullocks to be branded, so that each animal might be identified later.

31. I have performed another experiment to ascertain if by any chance bile in this province would confer immunity quicker than in other climates. For this purpose I injected calves with 10 c. cm. of bile and five days later tested them with virulent blood from Buffalo No. 5. They have all re-acted in temperature, three developed genuine rinderpest, and one died.

32. Experiments are proceeding.

VETERINARY-
CAPTAIN
RAYMOND'S
REPORT.

OXEN.

Professor Koch's Methods of

VETERINARY.
CAPTAIN
RAYMOND'S
REPORT.

APPENDIX I.

Post-mortem appearance.

Gall Bladder—was full containing a greenish fluid of a peculiar mild colour.

Lungs—were congested and emphysematous, which are the most characteristic points in the disease rinderpest.

Trachea Larynx and Bronchial tubes—were merely congested with an ulceration close to the vocal chords in the Larynx.

Buccal and Schniederian membranes—were almost all right, but patches of congestion here and there.

Rumen, Reticulum, Omasum and Abomasum.—There was congestion in the first stomach which is generally not found. The fourth stomach was highly congested and had a tendency of throwing off the mucous membrane.

Large and small intestines—were exanthamatus and infiltrated, but there was hardly any ulceration.

Heart, Liver and Kidneys—were almost normal.

APPENDIX II.

Post-mortem appearances of Bullock A, died of Rinderpest at Kanti on the 29th August 1897.

Mouth—normal.

Pharynx—congested bran-like deposit on the side of the Epiglottis.

Larynx and Trachea.—The former was congested with ecchymosis and the latter congested.

Lungs—Emphysematous, anterior tubes congested.

Stomachs—Rumen, Reticulum and Omasum normal: Abomasum highly congested and discoloured with erosions and croupous membrane and the mucous membrane thickened.

Intestines.—Small intestines congested with ecchymosis, croupous membrane, ulceration of Peyer's patches, mucous membrane thickened in places. Large intestines congested in patches and casts. Rectum congested in patches and stripes.

Spleen and Liver—normal, and Gall Bladder contained clear bile.

Kidneys—slightly congested.

Bladder—congested, with a few spots of ecchymosis.

Result.—Shot, 5th Sept.
1897.

Spleen.—Normal.

DIET ASST.

Notes of Case.

Name _____

Case Book No. 3.

Infected from Bullock
"A" suffering from Rin-
derpest on the 29th.
August 1897.

Bile taken for injection.

Not used on same day.

Injected 32 heads
of cattle on the 6th.
September 1897 at Du-
moria.

Date of Inoculation.

29th. Aug. '97 at 1-30 P.M.

Result.—Destroyed at
8 A. M., on the 5th. Sep.
1897.

Post mortem appearances of Buffalo No. 3, fed on dung and blood from a case of Rinderpest, and destroyed on the 5th September 1897.

Mouth, Tongue, Pharynx, Larynx, and Trachea.—Normal.

Lungs and Heart.—Lungs emphysematous and slightly congested and the latter normal.

Stomachs.---All stomachs normal except abomasum, which was congested and the mucous membrane thickened.

Intestines.—Small intestines congested with occasional patches of ecchymosis near the Ilio-Caecal valve and the mucous membrane thickened and corrugated.

Bladder.—The fundus of Bladder slightly congested.

Spleen, Kidneys, and Liver,—were all normal, but the mucous membrane of Gall Bladder was slightly congested.

[illegible]

APPENDIX VI.

DISEASE.

Rinderpest.

Notes of Case.

Buffalo.

Name

Case Book No. 4.

Infected from Bullock "A" with Rinderpest on the 29th. August 1897.

Bile taken and injected into 21 heads of cattle at Dumuria at 4 p.m. of the 7th. September 1897.

Serio.—K 1-xxi.

Date of Inoculation.

29th. Aug. '97 at 1-30 p.m.

Result.—Destroyed at 7-30 a.m., on the 7th. Sept. 1897.

1897.	August	29.	30.	31.	1.	2.	3.	4.	5.	6.	7.	Sept.
Time.												
Bowels.												
Urine.												
Temperature (Fahrenheit)	107°											
	106°											
	105°											
	104°											
	103°											
	102°											
	101°											
	100°											
	99°											
Normal Temperature of body.	98°											
	97°											
Day of Dis.												
Pulse.												
Resp.												
Date.												

Slight Catarrh
Discharge from the eyes of red
Diarrhoea
Erosions of cornea
Drooping of eyelids
Skin discolored

Post mortem appearance of Buffalo No. 4 fed on dung and blood from a case of Rinderpest, and destroyed on the 7th September 1897.

Mouth.—Erosions.

Pharynx.—Erosions with brany deposits and gelatinous effusions.

Larynx and Trachea.—Normal.

Lungs.—Congested and emphysematous.

Heart.—Normal.

Stomachs.—Only the last stomach congested and the mucous membrane thickened.

Intestines.—Small intestine congested with croupous membrane, caecum was congested with numbers of croupous membranes. Large intestines were exanthamatus with fibrinous casts and Rectum with stripes and patches and the mucous membrane thickened.

Spleen and Liver.—Normal, and Gall Bladder venous congested the mucous membrane thickened with petichæa.

Kidneys.—Slightly congested with serous effusion in and around.

APPENDIX VII.
DISEASE.

Rinderpest.

Notes of Case.

Buffalo.

Name

Case Book No. 5.

Infected from Bullock
"A" with Rinderpest on
the 29th. August 1897.
Enough bile was found
for about 40 injections,
but only 14 were inject-
ed at Dumuria.

Series.--L K I--xiv.
Blood was taken and
injected on 10th. at 8 A.M.
into Bullocks $\frac{K}{2}$ & 10
as tests.

Dose.--20-c. c. m.

Date of Inoculation.

29th. Aug. '97 at 1-30 P.M.

Result.--Destroyed at
9 A. M., on the 9th.
Sept., 1897.

1897.	August	29.	30.	31.	1.	2.	3.	4.	5.	6.	7.	8.	9.
Time.													
Bowels.													
Urine.													
Temperature (Rectal)	107°												
	106°												
	105°												
	104°												
	103°												
	102°												
	101°												
	100°												
	99°												
	98°												
	97°												
Day of Dis.													
Pulse.													
Resp.													
Date.													

Some skin eruption on testicle and

Slight discharge from eyes feeding fairly

Congestion of gums

V. M. M. (congested)

Post Mortem Appearances of Buffalo
No. 5, fed on dung and blood of
Rinderpest.

Skin.—Eruptions around the tests and
perinacium emphysema of subcutane-
ous areolar tissue.

Mouth.—Normal.

Pharynx.—Slight brany deposit.

Larynx and Trachea.—Normal.

Lungs.—Emphysematous and congested
anteriorly.

Heart.—Ecchymosis on the endocardium
of left ventricle.

Stomachs.—First three stomachs Normal
and the fourth one considerably
congested and thickened with 2 big
erosions.

Intestines.—Small intestines congested
and yellowish in places. Mucous
membrane thickened and Peyer's
patches enlarged. Caecum and large
Colon slightly congested with streaks.
Single Colon normal. Rectum slight-
ly congested with stripes.

Liver.—Congested and gall Bladder
congested with ecchymatic spots.

Spleen and Bladder.—Normal.

Test inoculations

DISEASE

Kind of pest

Notes of Case.

Name { ^K
 ^T
 2

Was inoculated with
10 c. cm. bile from
Buffalo N^o 1 on the
3rd September 1897.

Received on 10th Sept^r
20 c. cm. of defibrinated
virulent blood from
Buffalo N^o 5.

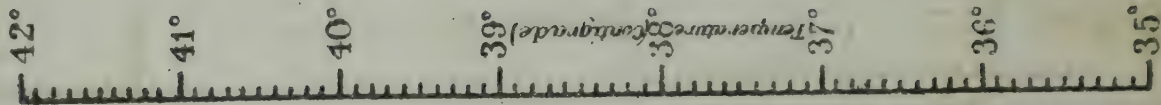
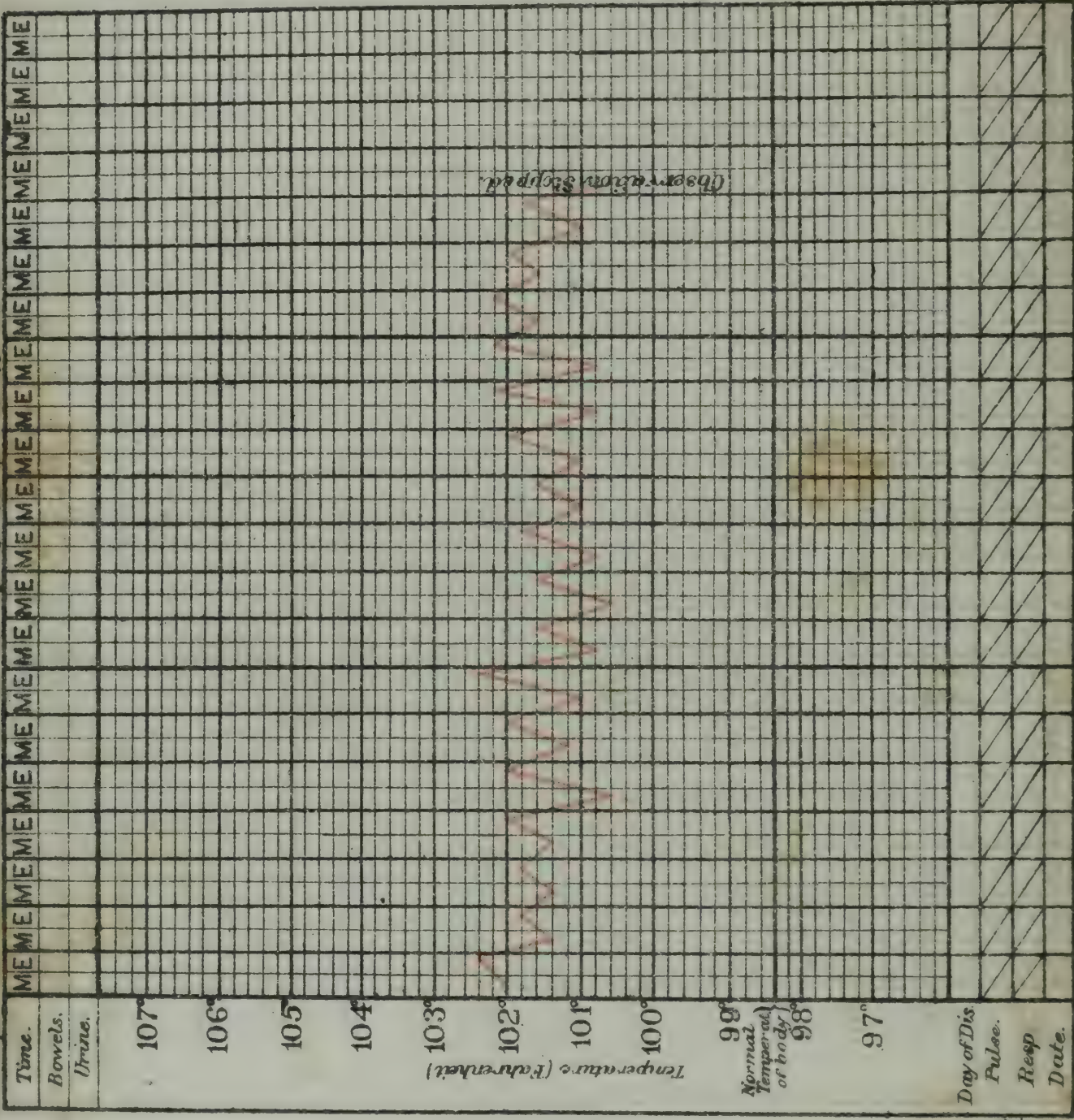
7th day.

Date of inoculation.

1st 3rd Sept^r 2^d 10th Sept^r

Result, Immune.

1897 Sept^r. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27.



Appendix IX

Test injections

DISEASE

Rinderpest

Notes of Case.

Name { ^K
 ^I
 10.

Bullock

Was inoculated with
10 c. cm. bile from
Buffalo N^o 1 on the
3^d September 1897.

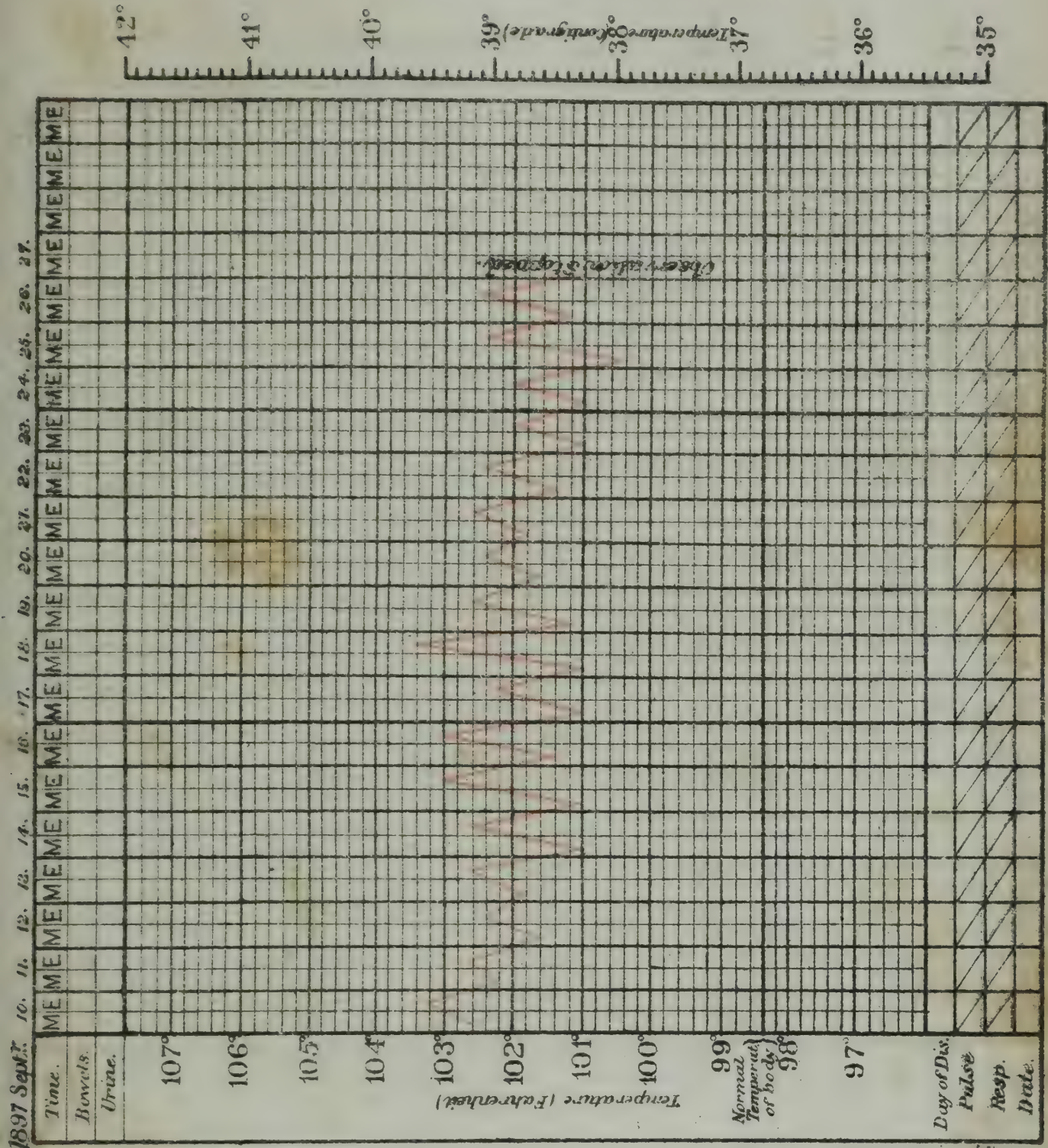
Received on 10th Sept^r
20 c. cm. of defibrinated
virulent blood from
Buffalo N^o 5.

7th day.

Date of inoculation.

Bile X⁴ 3 3^d Sept Blood 10th Sept^r

Result, Immune



Test inoculations

DISEASE

Rinderpest

Notes of Case.

Name { $\frac{K}{L}$ 15

Bullock

*Was inoculated with
10 c. cm. bile from
Buffalo No 3, on the
5th September 1897.*

Received injected
Subcut on 12th Sept.:
10 c.c.m blood from
Buffalo N^o 5.

7th day.

Date of inoculation

Bild 49 Sept. Blood 124 Sept.:

Result, Immune:

1897 Sept. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28.

Time.	Temp.	Pulse	Resp.	Date.
10:00	102.0	98	20	10/10/1918
10:30	102.0	98	20	10/10/1918
11:00	102.0	98	20	10/10/1918
11:30	102.0	98	20	10/10/1918
12:00	102.0	98	20	10/10/1918
12:30	102.0	98	20	10/10/1918
13:00	102.0	98	20	10/10/1918
13:30	102.0	98	20	10/10/1918
14:00	102.0	98	20	10/10/1918
14:30	102.0	98	20	10/10/1918
15:00	102.0	98	20	10/10/1918
15:30	102.0	98	20	10/10/1918
16:00	102.0	98	20	10/10/1918
16:30	102.0	98	20	10/10/1918
17:00	102.0	98	20	10/10/1918
17:30	102.0	98	20	10/10/1918
18:00	102.0	98	20	10/10/1918
18:30	102.0	98	20	10/10/1918
19:00	102.0	98	20	10/10/1918
19:30	102.0	98	20	10/10/1918
20:00	102.0	98	20	10/10/1918
20:30	102.0	98	20	10/10/1918
21:00	102.0	98	20	10/10/1918
21:30	102.0	98	20	10/10/1918
22:00	102.0	98	20	10/10/1918
22:30	102.0	98	20	10/10/1918
23:00	102.0	98	20	10/10/1918
23:30	102.0	98	20	10/10/1918
24:00	102.0	98	20	10/10/1918

DISEASE

Rinderpest

Notes of Case.

Name { ^K
 _L
 16
Bullock

Was inoculated with
20 c. cm. bile from
Buffalo N^o 3 on
5th September 1897

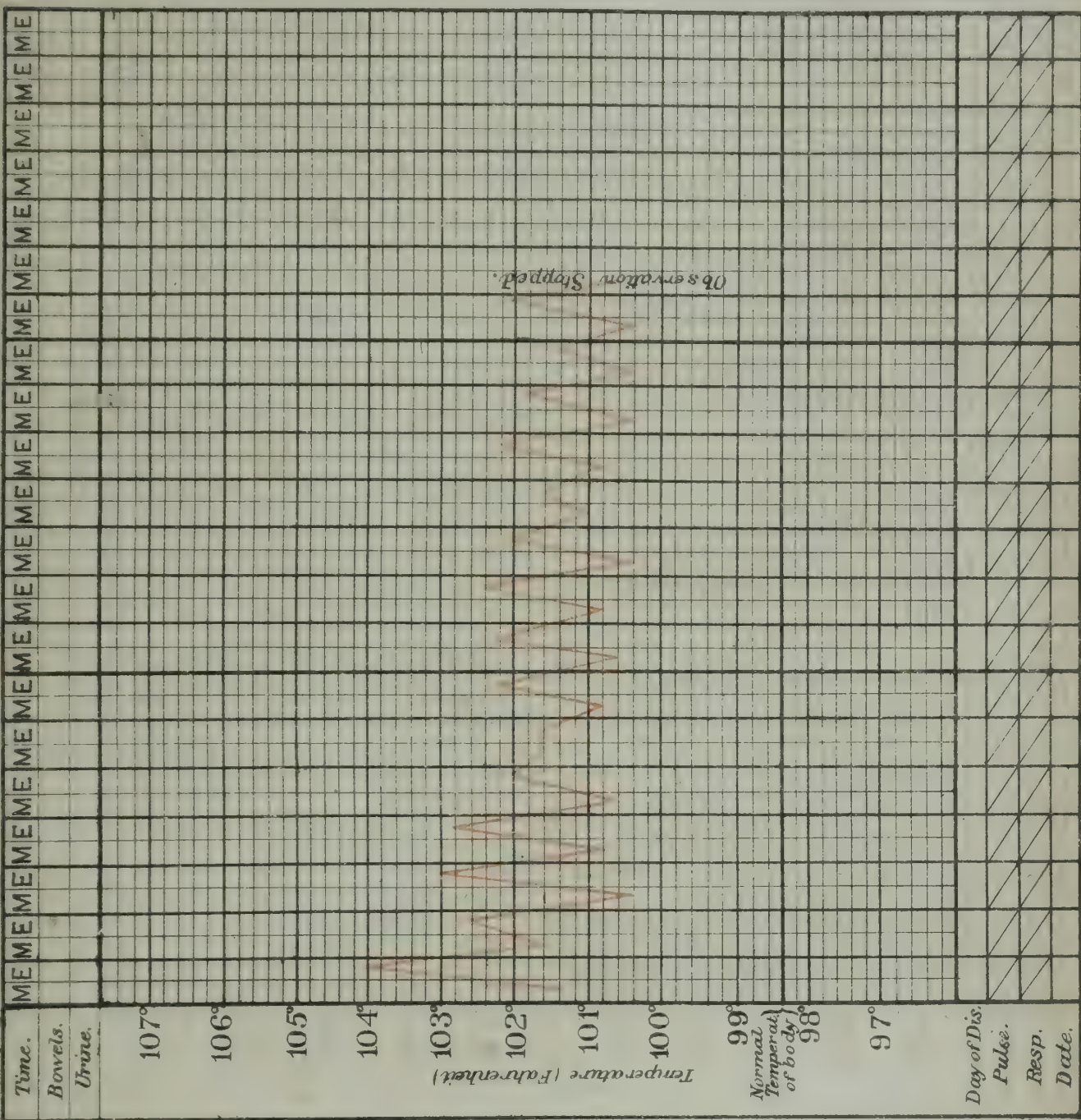
Received subcut.
20 c. cm. V. blood from
" Buffalo N^o 5 on 12th.
Sept^r. 1897.
7th day

Date of inoculation.

Bile 5th Sept^r. Blood 12th Sept^r.

Result, Immune

1897 Sept^r. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27.



OXEN.

Professor Koch's Methods of

VETERINARY-
CAPTAIN
RAYMOND'S
REPORT.

APPENDIX XII.

Post-mortem appearance.

Mouth—Excoriation of Buccal membrane, hard palate, dental pad, inside cheeks, lower lip, gums, under surface of tongue, soft palate and throat: the latter was much congested and discoloured.

Pharynx—congested and claret-coloured and excoriated.

Larynx and Trachea—living membrane congested and discoloured in patches.

Heart—Pericordium discoloured in patches: Endocardium marked with spots of ecchymosis.

Lungs—both congested, particularly the right one, and emphysematous.

Liver—clay-coloured and somewhat enlarged.

Gall Bladder—mucous membrane marked with patches of congestion.

Kidneys—both congested.

Spleen—also congested and somewhat enlarged.

Abomasum—very much congested, the anterior half being of a leaden hue and the posterior claret-coloured with excoriation and patches of extravasation.

Omasum—Epithelium easily peeled off, etc., and the blood vessels enlarged.

Reticulum—mucous membrane congested and its epithelium easily removeable.

Rumen—Epithelium easily removeable and it contained a large quantity of omphystoma Coimcum.

Small Intestine—contents were liquid, with large amount of viscid mucous and shreds: mucous membrane congested and marked with numerous patches of extravasation and several of the Peyer's patches ulcerated.

Large Intestine—mucous membrane congested in patches of scarlet colour and the contents were liquid with a large quantity of mucous castings and shreds.

Rectum—congested in patches and streaks.

Appendix XIII
Test inoculations

DISEASE

Rinderpest

Notes of Case.

Name { ^K
 ^L
 1

Bullock

Was inoculated with
20 c. cm. bile from
Buffalo No. 3 on the
5th September 1897.

Received injected
Subcutaneously 20 c. cm.
virulent blood on 16th
Sept 1897. from
Belgatchia sent obtain-
ed from a severe case
which died after 12 hours
removal of the blood

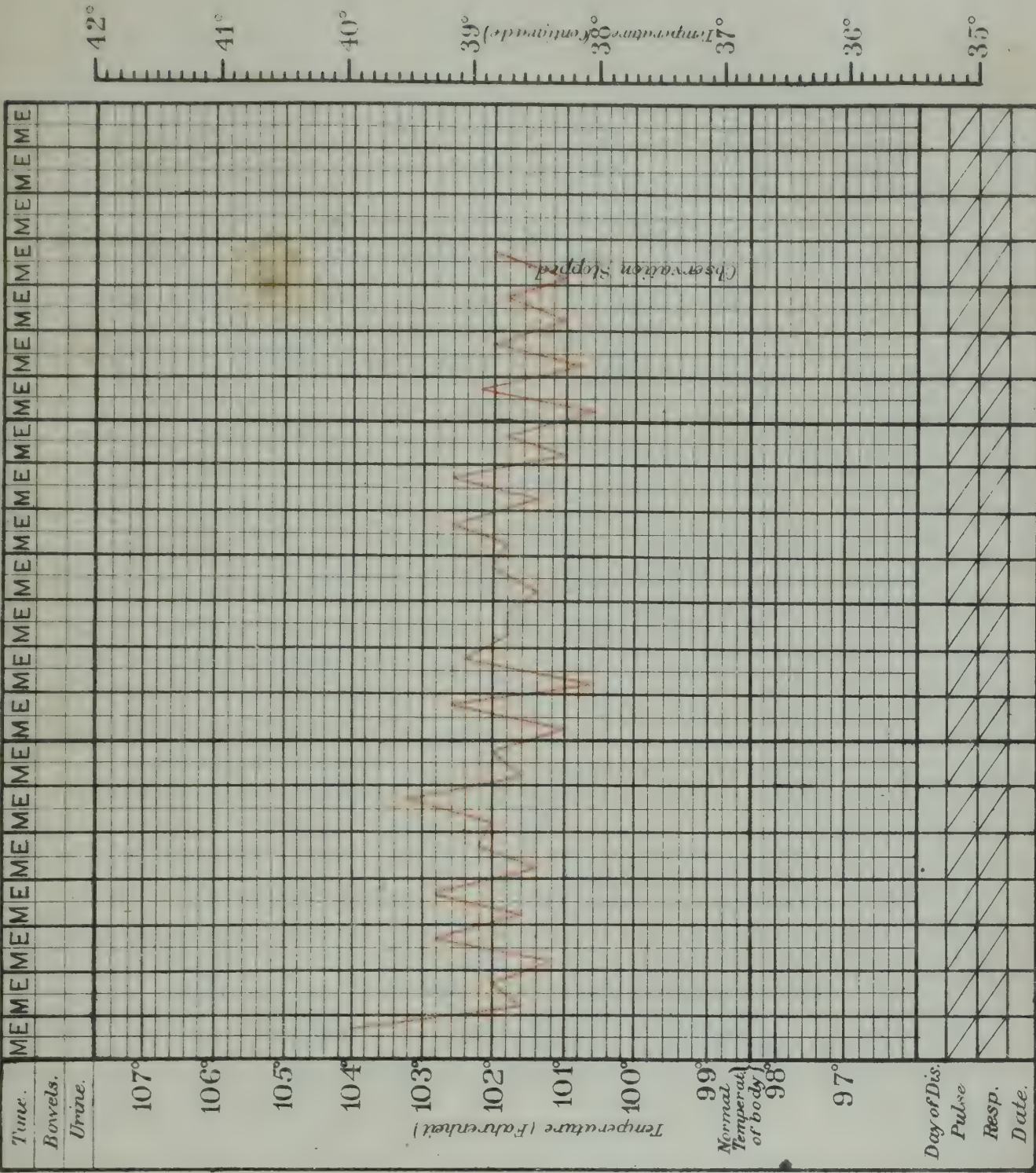
—11th day—

Date of inoculation,

Bile 5th Sept Blood 16th Sept.

Result, Immune.

1897 Sept. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 1. 2. 3.
Oct.



Appendix XIV
Test inoculations

DISEASE

Rinderpest

Notes of Case.

Name { ^{K.}
1.
2
Bullock.

Was inoculated with
10 c. cm. bile from
Buffalo No. 3 on the
5th September 1897.

Received injected
subcutaneously 20 c. cm.
virulent blood on 16th
Sept. 1897 sent from
Belgatchia and obtained
from a severe case of
Rinderpest which died
12 hours after removal
of the blood. -

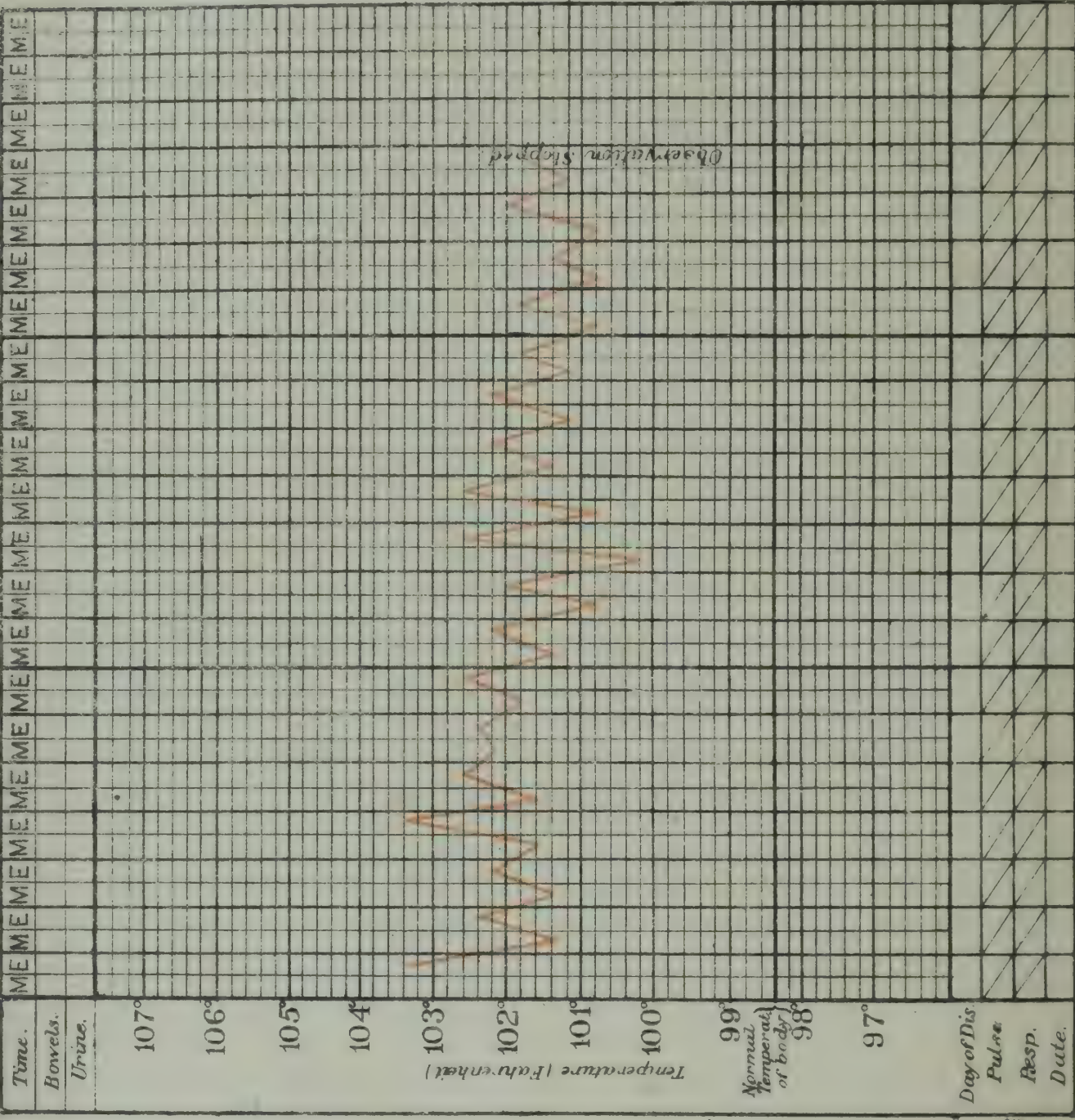
- 11th day -
Date of inoculation.

Bile 5th Sept & Blood 16th Sept.

Result, Immune.

1897 Sept. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 1. 2. 3.

Oct.



Observation stopped

Immunising cattle against Rinderpest.

OXEN.

REPORT OF VETERINARY-CAPTAIN EVANS.REPORT
of
VETERINARY-
CAPTAIN
EVANS.

7. Veterinary-Captain Evans, Superintendent, Civil Veterinary Department, Burma, after carefully describing the various methods adopted by Professor Koch, states :—

“In conclusion, from what I have said, it may be gathered that I consider trying experiments here, on the little experience I gained at Muktesar (and which in my opinion were not altogether a success), inadvisable. I feel convinced that Professor Lingard will obtain fresh virus and conduct further experiments. If successful, it will be time enough to begin here, I do not wish (unless ordered) to engage in any experiments until such time as I am satisfied that I may reasonably expect good results.

Professor Lingard at the Laboratory is, I fancy, the person best calculated to conduct experiments which are likely to afford the required information, as he has the time and facilities. I am strongly of opinion that it would be a great pity to be in too much haste to try experiments here which might end in failure, and thus cause the Burmans to lose all confidence in them, which would most assuredly be the case. When I hear that the protective method is successful, I have little doubt as to my ability to introduce it quietly, and in a short time to gain the confidence and assistance of the Burmans, in carrying the system out.”

OXEN.

Professor Koch's Methods of

VETERINARY-
LIEUTENANT
BALDREY'S
REPORT.

VETERINARY-LIEUTENANT BALDREY'S REPORT.

8. Veterinary-Lieutenant Baldrey, Assistant Principal, Bombay Veterinary College, makes the following remarks, after careful consideration of the methods adopted by Professor Koch:—

After inoculation with rinderpest blood, the temperature in four days goes to 104: then rinderpest evinces the usual symptoms. As far as I can see from personal observation, this system cannot be pronounced as an absolute certainty. One animal that I saw immunised, contracted a mild form of rinderpest when inoculated with virulent rinderpest blood, and I think that a great number of animals should be tried in different parts of the country, before going any further than to say that this system is any more than experimental. Up to now there is nothing to guide us in proving how long the immunity lasts: and this is a matter which would take at least two or three years to prove: an immunity of a few months would be of no practical value. An attack of rinderpest from which an animal has recovered, is known to produce a certain degree of immunity, but animals have been known to get the disease two or three times and even then die. I think it essential that some experiment should be tried in the Plains—say at the various Veterinary Schools—under systematic isolative precautions, as the climate is very different to Muktesar, which is at an elevation of 7,700 feet; and a variety of conditions are necessary to prove its invariable efficacy.

Up to now these experiments in India are Laboratory ones, in a favourable climate and under the most favourable conditions, so I think it necessary that something should be done in the Plains, and that animals should be exposed to all sorts of infection, such as they would meet with in the ordinary way: as it does not follow that if an animal is immune, against virulent blood, that it will also be immune to the infection that an infected herd would create, as it has been found in the case of Anthrax. It will be seen that an outbreak of rinderpest is absolutely essential to the carrying out of preventive inoculation, and that the bile from one dead rinderpest animal cannot be relied upon to do more than 10 (ten) animals, and that unless the inoculation be carried out by thoroughly competent men, it is more than probable that instead of rendering immunity, fresh centres of infection would be set up. I have said earlier in my report that the bile must be taken not later than seven days. This is because the duration of the disease, from the rise of temperature, is only seven days: if an animal lives longer than that, it has overcome the disease itself, so that it is very doubtful if bile taken after the seventh day, would be of use. This also requires experiments. I may briefly here explain how it is that rinderpest blood produces the disease, as they—both bile and blood—undoubtedly contain the poison of rinderpest. It is thus:—

“Blood when injected is immediately absorbed into the blood circulation in an unaltered condition, producing practically no inflammation at the seat of inoculation, and therefore causes the disease.

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Immunising Cattle against Rinderpest.

OXEN.

"Bile when inoculated, immediately causes inflammation, and consequent swelling: this swelling, which is as large as a child's head, inhibits the power of surrounding blood vessels and lymphatics to absorb the poison, and the action of the animal secretions in the affected part, have such an effect on the poison, that it loses its power to produce the disease but retains sufficient vitality to produce immunity. Bacilli of all kinds may occasionally be found in the bile, but this is accidental; they having found their way in from the intestine. None of these bacilli have yet been found to be rinderpest: they are ordinary putrefactive germs. No bacillus of rinderpest has as yet been isolated.

"Professor Koch has shown that the infection is carried a very short distance by flies (only the width of the standing room occupied by six or seven cows) and that cows will not get it in one end of an ordinary stable when diseased animals are standing in the other end. Actual contact seems essential, but infection by litter, discarded food, the boots and clothes of attendants, is conveyed to any distance and for any length of time."

VETERINARY-
LIEUTENANT
BALDREY'S
REPORT.

(Vegetable Product Series, No. 40.)
(Medicinal Products.)

THE
AGRICULTURAL LEDGER.

1898—No. 6.

—♦—
OROXYLUM INDICUM.

(SEEDS.)

[*Dictionary of Economic Products, Vol. V., O. 233-41.*]

DAMREE SEEDS.

THEIR REPUTED USE IN ALMORA AS A MEDICINE FOR CATTLE.

A Review of Correspondence on the subject with notes giving results of an analysis of the seeds by MR. D. HOOPER.

The interesting information conveyed in the following correspondence throws fresh light upon a product which has hitherto received little attention at the hands of Europeans in India. The bark of **Oroxylum indicum** is much better known to the natives of India as a medicine than the seed, and has long been employed as one of the ingredients of *Dasamula* or ten drugs mentioned by Sanskrit writers. The bark is used for various complaints administered internally, but as an outward application it is equally beneficial. Rheede noticed the use of the bark as an application to wounds and fractures. Boiled in Sesamum oil the root-bark is a remedy in otorrhœa, a muco-purulent discharge of the ear. The bark is also much used by the agricultural classes as an application to the sore backs of draught cattle; for this purpose it is ground to a paste with water and an equal proportion of turmeric, and rubbed on the part affected.

It is not very surprising then to find that the seeds have somewhat similar properties to the bark and are being used for like disorders as the following observations will show.

INTRODUC-
TORY.

Oroxylum
bark.

O. 233-41.

**OROXYLUM
indicum.**
Damree Seeds, a Medicine
**REVIEW
of
CORRE-
SPONDENCE.**

Damree
seeds.

From J. G. Bellairs, Esq., Proprietor, Chowkooree Tea Factory and Dairy Farm, Berenag P.O., Almora, to the Reporter on Economic Products to the Government of India, dated the 16th December 1896.

I am sending you by Parcel Post paid to-day the seed of a plant known here as "Damree," and I shall be very glad if you can inform me of its botanical name. The tree is found at 3,000 feet and lower, and sheds its leaves in winter. The seed (pod) I have had to cut in half for the convenience of sending.

The flaxy seeds found inside the pod are the best cure I know of for ringworm in calves, one or two mixed with some finely ground *bhut** (*Glycine hispida*) and administered to each calf night and morning, will cure the worst cases of the disease known here as "Damree" also. Whether the disease was named after the plant or the plant after the disease I cannot say.

Seeds
identified.

The seeds were identified by Dr. Watt as those of *Oroxylum indicum*, Vent., a tree belonging to the Natural order BIGNONIACEÆ. Our correspondent was informed of the name of the seeds and at the same time was asked for further particulars regarding the peculiar veterinary use to which the seeds were put. The following interesting reply was received in response to the request.

From J. G. Bellairs, Esq., Proprietor, Chowkooree Tea Factory and Dairy Farm, Berenag P. O., Almora, to the Reporter on Economic Products to the Government of India, dated the 13th January 1897.

Your letter of the 8th instant to hand yesterday, and I note that the tree known here as "Damree" is *Oroxylum indicum*. After sending you the pod I had come to the conclusion it was *Bignonia indica* from what K. L. Dey says in his book on indigenous drugs, and from Brandis' description of the tree.

Peculiar
Cattle
disease.

I am not wrong in saying the seed of the tree cures the disease known here as "Damree" for that I am quite certain of, but I may be wrong in thinking the disease is ring-worm. The disease is common amongst native owned cattle, but I never had a case in my herd until one year when I was given a Brittany bull and cow lately imported by Government. A calf was born about 3 months after arrival of the pair, and very soon after birth the calf got spots about the size of a 4 to 8 anna bit on the face, ears and neck from which the hair disappeared and which had a slightly red look. I was told the disease was "Damree," and that I should find a hard circle

* Otherwise known as the Soy Bean.—Ed.

for Cattle.	(D. Hooper.)	OROXYLUM indicum.
<p>about four annas in size on the roof of the mouths, and I was also told that probably all my calves would get the disease and sure enough all did. Natives said the seed of "Damree" was the cure, but none could then be got. These circles spread all over the animal till at last the calves look most peculiar. I washed with phenyle and gave sulphur internally, but could not see much benefit; I then continued the sulphur internally and applied it as ointment externally; paid great attention to keeping of the calves' houses clean, and once or twice a week either burnt sulphur or sprayed with phenyle, and in about 4 or 5 months the disease was beaten, but not before the worst cases had died. I was told that next year I might get the disease again in my calves, so I kept my eye on the houses and twice a month fumigated them, and in December laid in a stock of "Damree" seed. The disease did appear and on the first ring showing itself I did as the natives suggested and gave a seed or two with ground <i>bhut</i> (<i>Glycine hispida</i>) for a few days; few calves got more than 2 or 3 rings and these disappeared soon, and the calves not attacked, I presume from getting a few seeds, were never attacked. Now I do not fear the disease in the least, for directly it appears I dose every young animal with the seeds.</p>		<p>REVIEW of CORRE- SPONDENCE.</p> <p>Usual reme- dies tried,</p> <p>Damree seeds successful.</p>
<p>Veterinary-Surgeon Raymond was this way one year and I mentioned the disease to him, but could not show him a case, he said it might be ring-worm and so I called it that, but it may be something quite different.</p>		
<p>The calves attacked badly if not given "Damree," are covered with these rings which look exactly as if one had taken a metal seal and burnt the calf all over; the calves at first do not seem out of sorts, but as the number of rings increases they get thinner, have no spirits and the smaller ones will die; but calves of 6 to 9 months will generally pull through but they are miserably thin when over it.</p>		
<p>I am at 7,000 feet and "Damree" or <i>O. indicum</i> grows at 3,000 feet or in the Ramgunga Valley 16 miles from this, and it is not distributed everywhere in the Valley. I know the tree is to be got about Ranibagh and Kalidungi below Naini Tal, and I will send your letter to Mr. F. E. G. Mathews, a very old resident and interested in arboriculture, etc., and I will ask him to send you down what you want. He will find 50 trees at Ranibagh, whereas I might ride 16 miles and</p>		<p>Distribution of Oroxylum.</p>
<p>O. 233-41.</p>		

OROXYLUM
indicum.

Damree Seeds, a Medicine

REVIEW
of
CORRE-
SPONDENCE.Reference to
Veterinary
Department.

walk 3 or 4 along the valley without finding 3 trees ; when I want a few dozen pods it takes one of my men a week to get them.

No other part of the tree is valued in this district, except the seeds and they are only used for the disease known as "Damree."

On the receipt of the above letter from Mr. Bellairs, the Inspector General of the Civil Veterinary Department was referred to on the subject of the disease of cattle known as *damree*. It was considered the wisest course to obtain the technical name and a professional description of the disease, and to ascertain the value of **Oroxylum** seeds as a curative agent. The tree is so very common all over India that any special virtue attaching to its products should be investigated and made generally known.

The Inspector General, Civil Veterinary Department, in reply to the enquiries made by this office, obligingly forwarded a note on the disease drawn up by his assistant, and it was pointed out that it was very unusual for a disease of this nature to be treated solely by internal remedies, as they generally yielded only to such strong chemicals as silver caustic and acids.

From the Assistant to Inspector General, Civil Veterinary Department, to the Inspector General, Civil Veterinary Department, -No. 9, dated 14th April 1897.

Tinea
tonsurans.

With reference to your letter No. 263 C., dated 27th February 1897, I have the honour to state that the disease "Damree" alluded to, is similar to the disease **Tinea tonsurans**, and which is very common among young cattle in England. It is caused by the fungus **Tricophyton tonsurans**. Its constituents are smaller than those of **Favus**, and it does not project as cups on the surface, simply invading the epidermal structures and constituting a fine powder on the epidermis. It affects young animals especially when exposed to damp, and with dirty skins, and is readily transmissible from ox to ox, or to man and other animals. It attains a greater luxuriance of growth in the ox than in man, and the disease, when first received by man from the ox, is so luxuriant that it has been described as specifically distinct.

Symptoms.—Circular patches in various parts of the body, characterised by the absence of the hair the presence of vesica near the outer margin, and a scurfy condition of the central parts. Here and there in the ring may be seen a dry-looking hair, of a greyish

O. 233-41.

for Cattle.

(D. Hooper.)

OROXYLUM
indicum.

colour, somewhat twisted at the root, or the stump of a hair which has broken off. Magnin considers the true **Tinea** of the ox distinct from that of the horse, and terms it **T. decalvans** or **T. depilens**. This he finds to be generally nearly three times the size of **T. tonsurans**, to give rise to more formidable symptoms when communicated to the horse by inoculation, and to induce a different condition of the affected hairs. In calves, the disease affects the eyes, ears, neck, withers, and limbs.

Treatment.—These cases are usually treated with such remedies as Nitrate of Mercury, Nitrate of Silver or preferably Sulphurous Acid, but at the best the disease is difficult to relieve. It would be well to further test the seeds of **Oroxylum indicum** and communicate the results to the English Veterinary Journals.

The enclosures of the letter under reply are herewith returned.

Rev. A. Campbell, Manbhum, kindly furnished a supply of the seeds of **Oroxylum indicum** for chemical examination and experimental purposes. They are known in that district as *bana hatuk*.

The seeds are thinly discoid, flat, and very light buff coloured. They are winged and translucent (hyaline) all round except at the base, and the largest measure 3 in. by $1\frac{1}{2}$ in. When powdered they have a yellowish colour and a peculiarly rancid or oily odour, and a bitter and acrid taste.

Chemical Composition.—The powdered seeds exhausted with various solvents, and the moisture and ash at the same time estimated gave the following proximate composition—

Moisture	3.65
Oil	20.34
Resin and bitter principle	12.96
Mucilage and albumen	20.54
Fibre	32.71
Ash	9.80

100.00

The oil was green in colour, bitter in taste and fluid above 70°. The bitterness was due to a principle found also in the spirit extract of the seeds which had a distinctly yellow crystalline appearance. This principle was insoluble in water and gave a peculiar reaction with caustic alkalies which consisted in assuming a red colour passing

O. 233-41.

REVIEW
of
CORRE-
SPONDENCE.

RESULTS
of
CHEMICAL
ANALYSIS.

Composition
of seeds.

OROXYLUM
indicum.
Damree Seeds, a Medicine for Cattle.
RESULTS
of
CHEMICAL
ANALYSIS.

into a green on exposure to the air. This yellow substance is no doubt the same as that which was detected in the bark of this tree by Messrs. Naylor and Chaplin, and called Oroxylin (see *Pharm. Journ.*, September 27, 1890, *Pharmacographia Indica*, Vol. III. p. 16).

Composition
of Oroxylin.

Werner (*Beitr. Z. Kenntn. neuerer Drogen*, Diss. Erlangen, 1896) since the discovery of oroxylin has made a minute anatomical examination of the bark and has performed an elementary analysis of its bitter principle. He found 67.49 per cent. of carbon and 4.38 per cent. of hydrogen. At the same time he tried the physiological action of oroxylin. A frog after a subcutaneous injection of 150 m. gm. intimately mixed with water, exhibited no perceptible change. A rabbit treated in the same manner showed a rise of 1° of temperature in 3 or 4 hours, the respiration was accelerated and on the other hand, there was a decrease of the pulsation from 170-160 to 130.

Physiological
tests.
Seeds a
Famine food.

However active the seeds may be when medicinally applied, their potency is much reduced by heat and boiling. In Balrampur, during the famine of 1897, the seeds of **Oroxylum** were parched, ground into flour and made into bread. The agent of this district also reported that on some occasions the seeds were eaten raw. (*Innes*.) It would thus seem that there is nothing present of a decidedly poisonous nature in the seeds, and this opinion is supported by physiological tests made by Werner.

Bitter oils of
Melia and
Pongamia.

Bitter oils are much esteemed in India as applications for skin diseases. The oils of **Melia Azadirachta** and **Pongamia glabra** are widely used for these purposes, both on men and animals, and like many other remedies the nut of the seed is given internally while the oil is used as a lotion or liniment on the affected portion of the skin. Pitryasis and other parasitic affections have been removed by applying the bitter oils above mentioned, and there is reason to believe that the yellow active principle operates in the same manner as chrysophanic acid and destroys the growth of disease.

Mr. Bellairs is quite satisfied with the results obtained in using *damree* seeds for skin affections in cattle, and although the remedy might not accord with the usages of modern veterinary science, the publication of the facts may induce others to try a simple remedy within the reach of every Indian ryot.

O. 233-41.

G. I. C. P. O.—No. 139 R, & A.—20-7-98.—2,225.—B. N. D.

(Vegetable Product Series, No. 41.)
(Food Substances.)

THE AGRICULTURAL LEDGER.

1898—No. 7.

(Reprint from Assam Bulletin No. 4.)

PIPER NIGRUM.

(BLACK PEPPER)

[Dictionary of Economic Products, Vol. VI., Pt. 1., P. 811-20.]

CULTIVATION OF BLACK PEPPER IN ASSAM.

1. Note by MR. BHUPENDRA CHANDRA BASU, Assistant to the Director of Land Records and Agriculture, Assam.
2. Introductory Note by MR. D. HOOPER.

In publishing the interesting note by Mr. Bhupendra Chandra Basu on "Pepper in Assam," it would be well to preface it by a few general remarks on the cultivation of black pepper in India. The pepper vine (*Piper nigrum*, Linn.) is indigenous to the forests of Travancore and Malabar whence it has been introduced into Sumatra, Java, Borneo, Malaya and Siam. The earliest travellers to India observed the cultivation of the vine in Malabar and the important trade carried on in the spice between Europe and the ports of Calicut, Alleppy and Quilon on the Western Coast.

A wild pepper was found by Dr. Roxburgh in the hills north of Samulcotta on the Eastern Coast. The plant, on account of its sexual peculiarities, was named *Piper trioicum*, but according to later authorities, it is now considered to be nothing more than the wild form of *P. nigrum*. The author of the "Flora of British India" remarked in 1886 that "our knowledge of the specific limits of *P. nigrum* are as vague as of its geographical."

In Bombay the only district in which pepper is grown to any extent is Kanara. The varieties are named *kari malisaru*, *sambar* and

INTRODUC-
TORY.

Habitat.

Madras.

Bombay.

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PIPER nigrum.	Cultivation of Black															
INTRODUC- TORY.	<p><i>arsina murtiga</i>. The quality of the spice yielded by these three kinds of plants does not differ very materially, the difference consists in the crop the proportionate weight of which is greatest from the first named variety and least from the third. The pepper is fairly well established in the State of Mysore. In various parts of Burma the local demand for pepper, which is not very large, is said to be satisfied by its cultivation as a garden crop in villages, a system introduced by the Chinese.</p>															
Mysore.																
Burma.																
Bengal.	<p>Bengal imports large quantities of pepper from the Straits notwithstanding the heavy production of the spice in the country. The exportation of pepper from the Straits exceeds at the present time that from any other country and its quality is much esteemed.</p>															
Comparative weights of peppers.	<p>The general opinion of the trade is that Malabar pepper is superior in being the heaviest, and the merchant relies upon this test more than upon its appearance. Peppers are hence known as "heavy," "half heavy" and "light." Dr. Wynter Blyth in 1875 estimated the exact weight of 100 pepper corns belonging to different trade samples. The following was the result :—</p> <table><tr><td>100 pepper corns of Penang, weighed</td><td>.</td><td>{ 6.249 grams.</td></tr><tr><td>" " Malabar "</td><td>.</td><td>{ 6.053 "</td></tr><tr><td>" " Sumatra "</td><td>.</td><td>5.147 "</td></tr><tr><td>" " Trang "</td><td>.</td><td>{ 4.573 "</td></tr><tr><td>" " Tellicherry "</td><td>.</td><td>{ 4.507 "</td></tr></table>	100 pepper corns of Penang, weighed	.	{ 6.249 grams.	" " Malabar "	.	{ 6.053 "	" " Sumatra "	.	5.147 "	" " Trang "	.	{ 4.573 "	" " Tellicherry "	.	{ 4.507 "
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" " Sumatra "	.	5.147 "														
" " Trang "	.	{ 4.573 "														
" " Tellicherry "	.	{ 4.507 "														
Assam pepper Reg. No. 10701.	<p>The first two were bracketed together as standing first, Sumatra held the second place, and the last two the third.</p> <p>The Officiating Director, Department of Land Records and Agriculture, Assam, has kindly forwarded a sample of Assam pepper illustrative of Mr. Basu's paper. The fruits were smaller and more irregularly marked than the usual commercial samples. A weight test was taken of the pepper corns to compare their heaviness with other specimens. At the same time a sample of ordinary Bengal pepper from the Economic Gallery of the Indian Museum was tested with the following result :—</p> <table><tr><td>100 pepper corns of Bengal, weighed</td><td>.</td><td>6.157 grams.</td></tr><tr><td>" " Assam "</td><td>.</td><td>3.082 "</td></tr></table>	100 pepper corns of Bengal, weighed	.	6.157 grams.	" " Assam "	.	3.082 "									
100 pepper corns of Bengal, weighed	.	6.157 grams.														
" " Assam "	.	3.082 "														
Compared with Bengal pepper Reg. No. 3618.	<p>The Assam pepper was only half the weight of the Bengal which compared favourably with that of good commercial fruits. It is possible that in Assam the cultivators have not paid sufficient atten-</p>															

P. 811-20.

Pepper in Assam.	(B. C. Basu.)	PIPER nigrum.
<p>tion to collecting the crop as the fruit begins to ripen. If collected when too young or allowed to hang on the tree after they are ripe, the pepper corns deteriorate in appearance, solidity and value.</p>		CULTIVATION
<p>It is not perhaps generally known that black pepper is cultivated as a garden crop in certain parts of Assam. The writer of the article on black pepper (Piper nigrum) in Dr. Watt's <i>Dictionary of Economic Products</i> does not mention its cultivation in Assam; the only reference made in that article to Assam is to the effect that black pepper is doubtfully indigenous in the forests of this province.* I have found black pepper being grown in many villages in the Sibsagar district. It is chiefly found in some villages in mauza Gadhuli Bazar in the west of the Sadar sub-division. In this mauza is a village Jalukgaon, named after the Assamese word for black pepper. It is currently reported to have been the chief seat of pepper cultivation at one time. In Lower Assam the cultivation of black pepper is reported to be unknown. On the other hand, a little of it is to be found in Sylhet and on the southern slopes of the Khasi Hills bordering on that district. The crop is not, however, cultivated to any appreciable extent in any part of Assam. It is usually cultivated to supply the cultivator's own requirements, and what is left over after meeting his own wants is sold. The aggregate quantity of black pepper produced in Assam is indeed very small, and very little of it finds its way to the market. Assam continues to derive its supply of this spice chiefly from Calcutta, although there is no apparent reason why it should not grow the whole of it, and have more to spare.</p>		<p>A garden crop occasionally met with.</p> <p>'Black pepper village.'</p> <p>Not extensively cultivated.</p> <p>Supplies mostly imported.</p> <p>Vernacular.</p> <p>Assam pepper smaller than the foreign article.</p>

* From enquiries I have made, black pepper does not appear to occur in the wild state in any part of the Assam Valley, but an allied species (*P. longum*), the *pipal* or long pepper, is so found.

PIPER nigrum.	Cultivation of Black
CULTIVATION	indigenous article is, however, more pungent, perhaps because it is more fresh, and, therefore, commands a higher price in the local market.
Trees employed as a support for the vine.	<p>In Assam, the black pepper vine, like the betel vine (Piper Betle), is usually grown on betel-nut trees (Areca Catechu), mango (Mangifera indica), jack (Artocarpus integrifolia), and other garden trees are occasionally utilised for the purpose; but of all trees the betel-nut is regarded as the most convenient and suitable for raising <i>pan</i> and black pepper. It is planted immediately around the raiyat's homestead, and receives more manure, labour and care than any other tree or crop grown by him. The rearing of betel and pepper vines in association with this tree entails but little additional labour on the cultivator. The plucking of the leaf in the case of <i>pan</i> and of the ripe berry in the case of black pepper is also very convenient when these are grown on the betel-nut trees, as by the simple application of a ladder every part of the vine can be easily and quickly reached.</p>
Betel-nut tree :	<p>The pepper vine is raised either from suckers which spring up from underground roots or from shoots from the stem. Shoots when used, are bent down into the ground to strike root before they are severed from the mother plant. The young plants are taken out with their roots at the beginning of the rains, and transplanted at the foot of the trees on which they are intended to grow. Generally, only one plant is put down at the foot of each tree. The slender stem of the young vine requires in the beginning to be carefully tied on to the supporting tree. As it grows up, it throws out from each joint numerous bunches of short claw-like adventitious roots, which penetrate into the soft outer bark of the supporting tree, and give the vine a firm hold upon the latter. New shoots and suckers continue to appear, and growing up the tree, envelope it in the course of a few years with a dense mass of foliage.</p>
Advantage of.	<p>The subsequent treatment of the black pepper plant cannot be distinguished from that of the betel-nut tree, with which it is mostly associated. Like the latter, it requires to be very liberally manured. Cowdung and household refuse are the only manures in use in Assam and of these as much is given as the cultivator can afford. The manure is applied at the end of the rains and at intervals all through the cold weather. It is simply heaped up round the base of the tree on which the vine grows, and affords nutrition to both. The</p>
Manner of rearing the vine.	P. 811-20.
Later treatment of black pepper and betel-nut very similar.	

Pepper in Assam.	(B. C. Basu.)	PIPER nigrum.
<p>manure heap serves the further purpose of protecting the vine from cold and drought. To keep in the moisture in the manure heap, pieces of the thick juicy bark of a plantain tree are ranged round the base of the tree and renewed from time to time. A betel-nut plantation, whether <i>pán</i> or pepper be grown there or not, must be hoed, and cleaned once in the year at the close of the monsoon rains; a careful cultivator would repeat the operation thereafter and until the rains again set in as often as he could spare time and labour for the purpose. The ground should be kept as clean and free of jungle as possible at all times of the year. In May, the manure heaps are levelled down and spread over the ground, otherwise they would absorb too much moisture and cause the roots of the vine to rot.</p>		CULTIVATION
		Manuring.
<p>The pepper vine is very susceptible to drought, which often proves fatal. Rain and fog in the cold weather cause the leaves to fall off, and are consequently dreaded by the cultivators. The plants then remain bare until the first warm showers of April, when new leaves re-appear. Hailstorms are a frequent source of injury to black pepper and other crops in Assam. Some damage is also caused by a species of caterpillar which feeds on the leaves of the pepper vine. When it appears, it is destroyed as far as possible by hand-picking.</p>		Hoeing and cleaning.
		Climatic conditions which are unfavourable to the plant.
<p>The black pepper vine begins to bear in from three to five years after planting, and continues to yield for at least twenty years. In every plantation, there are usually one or more vines which neither flower nor fruit. These are called <i>matá</i> or males, and the rest which bear fruit are known as females. The vine flowers in May and the berries are plucked in December. They are gathered when just beginning to ripen. If allowed to ripen fully they fall off and are picked off by birds. Pepper is cured in Assam in two different ways. If intended for the cultivator's own use, the berries would be boiled in water for a few minutes in order to soften the husk, which would then be removed by rubbing the berries over a bamboo basket. The spice so prepared is of a whitish colour, and more pungent than the kind prepared for the market. For this latter purpose, the berries are simply dried in the sun after boiling, and allowed to retain the husk, which assumes a black colour, and gives the black pepper of commerce its distinctive name.</p>		Insect pest.
		Longevity.
		Unproductive vines.
		Seasons of flowering and harvesting.
		Curing.
		Two methods.

PIPER nigrum.	Cultivation of Black Pepper in Assam.
CULTIVATION	<p>The produce of a vine varies with its age and size and the character of the season. The highest outturn that can be obtained from a single vine is said to be about three seers of dry cured pepper ; the average yield is commonly reported to be about one seer for each vine in a plantation. The retail price of Assam black pepper varies from 10 annas to a rupee per seer, and the wholesale price from R17 to R20 per maund. An acre of betel-nut plantation can hold about 500 trees, and if each tree had a pepper vine on it, the annual yield of pepper alone from the plantation might amount to over 12 maunds, valued wholesale at R200 to R250.</p>
Yield.	
Prices.	
G. I. C. P. O.—No. 82 R. & A.—20-7-98.—2,225.—B. N. D.	

THE
AGRICULTURAL LEDGER.

1898—No. 8.

SACCHARUM:
(SUGAR AND SUGARCANE.)

[*Dictionary of Economic Products, Vol. II., Pt. II., S. 126—40.*]

CULTIVATION OF SUGARCANE IN THE BOMBAY PRESIDENCY.

Note by Mr. J. W. MOLLISON, Deputy Director of Agriculture, Bombay Presidency, with Descriptions of Varieties of Sugarcane by Mr. MOLLISON and Dr. J. W. LEATHER, Agricultural Chemist to the Government of India.

CULTIVATION.

The crop is cultivated in almost all parts of the Presidency and on a greater variety of soils than any other irrigated crop. It adapts itself to almost any description of soil if drainage is secured by a pervious sub-soil or by artificial means. A water-logged condition of soil is perfectly fatal to successful cane cultivation. In other respects any description of soil of fair depth suits one or more of the many varieties cultivated throughout the Presidency.

2. The varieties may be broadly grouped into two types, but there are numerous gradations between the two extremes :

- (a) Thick, juicy, soft kinds which ordinarily require copious irrigation frequently given.
- (b) Thin, very hard, less juicy kinds which require lighter irrigation at longer intervals.

3. On the very light alluvial soils of Ahmadabad and of Bassein and elsewhere on the Thana coast and on the richer alluvial loams of the garden villages of Kaira, Baroda and Surat excellent crops of varieties of "A" type are grown. These lands are almost continuously irrigated from wells and the cane is rotated with other garden crops such as ginger, turmeric, elephant's foot (*Surans*), yams, potatoes, sweet-potatoes, ground-nut, plantains and betel-vines.

4. In the Surat District sugarcane is not confined to soils of the above description only. It is also grown on black soil, slightly tinged with brown, about 4 feet deep, with a deep substratum of yellow earth which consists of an intimate mixture of sand, clay and lime. The sub-soil is fairly pervious to water. Cane is planted in such soil in artificially

CULTIVATION.

Soils
suitable.

Different
types.

General
distribution
of the crop
in the Pre-
sidency.

Cane in
Gujarat.

SACCHARUM:
Sugar.

Cultivation of Sugarcane in the

CULTIVATION.

embanked fields which also grow rice, or on higher drier land ; but in either case there is always an interval of several years, usually 4 to 6, between two successive cane crops. Thick soft and thin hard varieties are often grown mixed on such land. It is not clear what advantage there is in growing the two kinds mixed, except when a border of a thin hard variety on the headlands surrounds the soft succulent variety. In this case it is currently believed that less damage is done by jackals and pigs. These pests are supposed to sample the hard cane on the headlands and finding it hard or not very sweet they pass on to a field with a soft succulent variety. Very often the two types are mixed indiscriminately all over the field. The same practices are also common in the Southern Marátha Country. The Surat District has great variety of soil and considerable range in the average rainfall between Tálukas. It is therefore not surprising that eight distinct varieties of cane should be found in general cultivation and at least six of these are different from any found in the Deccan or the Southern Marátha Country, and two are so distinctively coloured that they cannot be referred to any type found in other parts of the Presidency. These colours in each case can best be described as dirty.

**Cane in
Southern
Marátha
Country.**

5. In the Southern Marátha Country, cane is grown to a large extent on the favourably situate low-lying brown or red-brown laterite soils which also grow rice, and, where good perennial irrigation facilities exist, also grow many other garden crops. On this class of land, also on medium black soil, cane is grown at intervals of 3 to 5 years. A cane of peculiar colour is here in common cultivation. It has alternate longitudinal stripes of purple and green. Similar cane is sparingly cultivated in Khándesh and in the Nira valley (Poona District), but not elsewhere in the Presidency as far as I know. In the Southern Marátha Country the general style of sugarcane cultivation is not so advanced as in some districts.

**Cane in the
neighbour-
hood of
Poona.**

6. The most suitable soil for cane in the neighbourhood* of Poona is black or mixed black, got from decomposed trap. It is a stiff clay loam $2\frac{1}{2}$ to $3\frac{1}{2}$ feet deep, resting on *murum*, which is shaly limestone very pervious to water. This combination of soil and subsoil secures good natural fertility associated with good natural drainage. Only one variety of cane "Pundia" is grown near Poona. It is a particularly good variety and possibly few, if any, other varieties cultivated in other districts surpass or equal Pundia for the production of *Gul* or crude-sugar. The cultivation of Pundia is rapidly extending in other districts.

**Period of
growth.**

7. Sugarcane is commonly called a 12 months' crop. Some varieties ripen earlier than others. A crop which has been heavily manured with a quick-acting manure may be forced to maturity in perhaps 11 months, whilst a crop treated with a slow-acting manure may take 12 or 13 months to ripen. Again, a crop which is repeatedly top dressed with manure continues to grow longer and probably also yields better than a crop grown with the same amount of manure applied entirely before plantation. Ratoon cane ripens in less time than newly planted cane. In the neigh-

Bombay Presidency.

(James Mollison).

SACCHARUM:
Sugar.

CULTIVATION.

bourhood of Poona cane planted late in March or early in April under canal irrigation is often allowed to stand over two monsoon seasons or for 18 months. Very often this practice pays, because although the cane deteriorates, the extra price that *Gul* brings (usually 50 per cent more than in the ordinary season) more than compensates for the loss. The extra charge for canal water is not much and there are no other extra expenses worth considering.

8. Cane is planted in different localities at different seasons. In Ahmadabad, Kaira and Baroda, it is planted in May or early in June. The soil is of sandy character. White ants are very destructive on this class of land, particularly whilst the cane is young. The white ants do not do much harm during the monsoon to sugarcane, because on dry crop areas there is much vegetable growth at this season which supplies the white ants with food and the pest being widely distributed over large areas, the damage done is not particularly noticeable; therefore if the cane is planted in May it practically escapes damage whilst young. In the Surat District, also in the Southern Marátha Country, most of the cane is planted in November and December, but the season may extend to February. In the Poona District, February and March are considered the best months to plant. The season of planting depends somewhat upon local conditions. Generally speaking any season is suitable for planting except the hot weather. Young shoots suffer considerably from the hot sun, and a check received at this time from this cause or in fact from any cause is not afterwards recovered.

Seasons of
planting.

9. The crop is propagated from sets, sometimes, as in Gujarát, by planting whole canes. The sets consist of pieces of cane generally about a foot long. Each set has usually three eye-buds, sometimes more, and then the set may be 15" to 18" long. When sets are planted beds are generally previously formed. The sets may be planted at the required distance apart in pits dug out with a small pick and 3 to 4 inches deep. One set is planted in each pit. The pits are in straight rows. The sets when carefully covered with soil are 4 to 6 inches apart in the rows and the rows 2 feet distant from each other. The beds are left level. This practice is common in Baroda. Water is given immediately after planting. Sometimes three or four sets are planted together in a pit, each pit being about 6" deep and 12" to 15" square. The pits are about 2 feet apart from centre to centre. The cane then grows in clumps which stand up well in heavy wind or rain and which if bound round by dead leaves are not easily much damaged by jackals or pigs. The beds in which the clumps stand are left level. In the Southern Marátha Country it is customary, after the field is well prepared and manured, to plough it into ridges and furrows and, after watering, trample in the sets in the furrows. When the soil dries, the harrow or light plough is used to level the ridges over the planted sets and to work the land smooth and friable, so that when the cane sends up shoots,

Propagation
and methods
of planting.

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these may be earthed up with the plough which is worked between the rows and forms furrows which serve as water channels for temporary irrigation. Subsequently beds are formed for regular irrigation, but in the case of hard varieties of cane requiring little water the surface is left level, the rows not being earthed up and the irrigation water is led over the field in the best way the cultivator can. This is not a desirable method, but when adopted in order to economize irrigation water as much as possible grass is spread over the surface and a fine layer of earth is put on the grass. This conserves moisture and therefore fewer waterings are required. In the Dhárwár District the following is a common method of planting. Cane sets are put in furrows which are made by the plough. The sets are placed 3" to 6" apart and are 12" to 15" long. Planting is done in February. The field is immediately watered. It is not laid out in beds at all. About a handful of manure is put over each set at time of planting. When the soil dries after the first watering the ridges are split with the plough. This is done before young shoots spring up. The sets now occupy the ridges and the furrows serve as water channels for irrigating the crop and extend along the least slope, generally either the whole length or breadth of the field.

When whole canes are planted a heavy plough is used. The canes are passed through a hole drilled in a slanting or inclined backward direction through the body of the plough and are left imbedded in the soil in the furrow and about 6 inches deep. This operation is facilitated by a man following the plough and trampling each cane into the furrow as it is pushed through the hole in the plough. The seed rate is calculated in lengths of 6 *hāths* (about 9 feet), about 2,500 six-*hāth* lengths are planted per acre. Very few single canes are each 6 *hāths* long. This method of planting is of doubtful advantage for various reasons. It is slow. The cultivators of the districts where this method is practised think it is most expeditious; but this conclusion is wrong. Many of the eye-buds are destroyed in passing the cane through the plough. Planting is commonly done in this way on black soils in the Surat District. If the plough is carefully guided the rows are moderately straight and are about 20 to 24 inches apart. After planting, the surface is smoothed and made into temporary shallow beds, and enough water is given literally to swamp the field. As soon as the soil dries, the light plough is worked to stir the surface soil to a depth of about 3 inches. The sets are planted below this level and are not disturbed by the light plough. This light ploughing may be done twice. It kills weeds and leaves the surface soil loose and friable so that when the rows of young shoots are well up, they can be earthed up and beds can be easily formed in the ordinary way for regular irrigation. The second watering is not given for six weeks or two months after plantation and generally not more than 12 to 15 waterings are given during the year and in artificially embanked land only 9. Deep black soil is, of course, very retentive of moisture and the cane being planted

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deep is favourably placed for moisture ; still the practice of withholding water for a period of two months after plantation is by no means common. It is generally conceded that at least the soft succulent varieties of sugarcane on almost any class of land, if grown from sets, require frequent light irrigation until the young shoots are well up.

10. There is no doubt that there is considerable advantage in planting cane deep except on very retentive soil. If planted deep, the roots get a firm hold of the soil and the canes are more or less supported so that a heavy crop is not likely to be lodged by rain or wind. If planted deep in dense heavy soil germination is interfered with ; at least cane will not germinate evenly if planted in this way on such land.

11. The Mauritius system of planting is, I believe, advantageous on any description of moderately free working soil. In this system pits, a foot sometimes more in depth, are dug about a yard apart in each direction. 2, 3 or 4 sets are planted in each pit and covered carefully. If the pits are deep they should not be filled up level with the surface until the young shoots appear above ground. Beds are formed for irrigation. Recently introduced Mauritius varieties do well when planted in this way, and it is probable that such Indian varieties as freely tiller would also succeed ; but experimental trials are necessary.

12. In most districts of the Presidency sugarcane is rarely grown on the same land at shorter intervals than 4 to 6 years. Nowhere except in the Poona District is cane grown continuously for several years and in no other district is ratooning practised to any appreciable extent.

13. A ratoon crop is one grown from the root stocks of the previous crop. There is clear evidence from the experiments at Mánjri that it is risky in the Poona District to take more than one ratoon crop. If new cane is planted on clean land, as of course it ought to be, there is little difficulty in keeping the new cane free of weeds particularly if the crop is heavy. It is not so easy to keep the succeeding ratoon crop quite clean. In the third year it is well nigh impossible, however careful the tillage may be, to prevent *Hariáli* (*Cynodon Dactylon*) and other grasses and weeds becoming more or less established. The young shoots of the second year's ratoon come up weaker than those of the first year. The root stocks of the former get overgrown to the extent that the distribution of irrigation water is interfered with. Throughout the Poona District two successive ratoon crops are generally taken. The first ratoon crop gets generally a lighter dressing of manure than new cane and the second ratoon crop gets a much lighter dressing, sometimes none at all. It is quite likely that residues of heavy dressings given to new cane and the first year's ratoon would suffice for the second ratoon crop without any direct application. Ratoon cane grown in this way would probably pay, even though a poor crop, because the cost of manure is by far the heaviest item in the cost of cultivation. On the other hand, deep-rooted grasses and other weeds

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Deep
planting
advantageous.The Mauritius
system of
planting.Cane usually
grown at
intervals of
several years.

Ratoon cane.

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might get thoroughly established. The cost of cleaning and fallowing would be heavy. The profit from first ratoon is greater than from new cane. The preparatory tillage for the former is trifling. There is no expenditure for sets or for planting. Less irrigation and less manure is required.

I tabulate below outturn &c. results from first and second year's ratoon grown on comparative plots at Mánjri (Poona). The plots were equally manured to secure fair comparison. Rather heavy dressings of manure were given. In ordinary practice less manure would probably have been given to the first year's ratoon and certainly to the second year's crop.

First year's ratoon.

Manure.	Weight of manure per acre.	Weight of cane stripped and topped per acre.	Outturn of <i>gul</i> per acre.	Cost of cultivation per acre.	Value of produce per acre.
Safflower and ground-nut cake	Tons. 3.3	lbs. 68,030	lbs. 7,689	Rs. a. p. 320 10 0	Rs. a. p. 426 10 0
Poudrette	22.65	73,580	8,055	324 14 0	447 8 0

Second year's ratoon.

Safflower and ground-nut cake	3.3	38,510	4,095	292 4 0	227 8 0
Poudrette	22.65	34,530	4,040	301 14 0	224 7 0

Possibly if a much lighter dressing of manure had been given to the second year's ratoon as in ordinary practice the crop would have paid fairly well.

14. Cane is grown almost continuously under canal irrigation in the Poona District. Occasionally the land is fallowed and rested for few months, and when thoroughly clean, a green manure crop of *San* (**Crotolaria juncia**) is grown and ploughed in. This crop is everywhere recognized as a good preparation for sugarcane. A green manure crop of *Kulthi* (**Dolichos uniflorus**) is also considered in the Deccan a good preparation. Ground-nut before sugarcane is considered good practice if the ground-nut is well manured. The cultivation of sugarcane in the neighbourhood of Poona is perhaps typical of what it should be elsewhere, and may therefore be fully described. The best soil is a clay loam and the best preparatory crop is a green manure crop of *San*. The *San* should be sown thickly in June or July (about 70 lbs. seed per acre) and ploughed in when 3½ to 4 feet high. The crop, if thick, smothers surface weeds. It enriches the surface soil with a mass of organic matter which quickly decays and therefore leaves the soil open and friable so that subsequent tillage operations can be done quickly and well. If no green manure crop has been grown

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the land is allowed to lie waste during the monsoon. This is objectionable, because grasses and other weeds get established and subsequent tillage and cleaning operations are expensive. The field is deeply ploughed in November with a large eight-bullock plough, an acre being covered in about 4 days. The soil is turned up into huge clods and is allowed to weather before it is cross ploughed. One or two subsequent ploughings in December improve the tilth considerably. Most of the clods break up into smaller nodular pieces and the soil becomes easily moved to a depth of about 10 inches. I may note that I have been able to accomplish the ploughing operations for sugarcane with Ransome's Turn Wrest plough quite as effectively as with the best pattern of indigenous plough and at considerably less cost for manual and bullock power. I advocate the use of the Turn Wrest plough for sugarcane and other garden crop cultivation; but for ordinary dry-crop cultivation I cannot conscientiously urge that this plough or any other iron turn-furrow plough is as good as the best indigenous implements. After thorough ploughing the surface is levelled with a log harrow and clods are broken, if necessary, by hand with a mallet or thick short stick. Then manure is applied. Poudrette or farm-yard manure are most commonly used in the Poona neighbourhood, 60 loads or say 30 tons of either per acre being the usual dressing. If so much is given before plantation, the crop gets no top-dressing afterwards; but usually a smaller application of poudrette or farm-yard manure is given before plantation and the crop is top-dressed in June or July with castor cake, *karanj* cake, fish manure or other concentrated manures.

15. It has been proved by the Mánjri experiments, which will be referred to in detail further on, that certain manures are more active and effective for sugarcane than others, and that apparently the most important constituent of manures for sugarcane is nitrogen in immediately available condition. The experiments clearly indicated, if they did not absolutely prove, that nitrogen in this form was absolutely essential to feed the young shoots during the early stages of growth. The sugarcane set itself contains very little on which the young shoot can feed. Therefore in the case of land in low condition the manures to be applied before plantation should be such as are known to be quick-acting, as for instance, poudrette, fish manure and the various country-made oil cakes. Farm-yard manure, which has the reputation of acting slowly if used, should be thoroughly decayed before application. In this condition it will probably act more effectively and quickly.

16. It has yet to be proved what is the most economical dressing of nitrogen that should be given to produce the best results. DR. LEATHER has shown by analysis that even a heavy crop of sugarcane does not take up more than 100 lbs. of nitrogen per acre, yet if all the manure is applied before plantation, as it ordinarily is in common practice, at least 400 lbs. of nitrogen per acre must necessarily be given for the best results.

Nitrogen in immediately available form necessary for cane in the early stages of growth.

What is the most economical dressing of manure for cane.

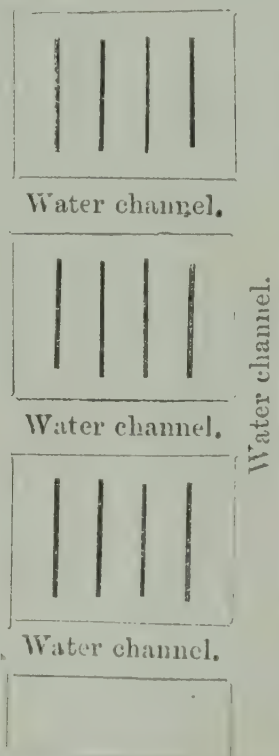
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Top dressing
recommended.

To provide this quantity of nitrogen, probably about 30 tons per acre of ordinary cowdung and compost manure would be required. If this application contains the required quantity of nitrogen, it will certainly contain sufficient of other important elements of nutrition.

17. There can be little doubt that the copious irrigation necessary for sugarcane washes manure away in the drainage. DR. LEATHER has proved by analysis that during the process of the manurial experiments at Mánjri the soil has accumulated fertility and that manures not removed by the crops are still to a large extent in the soil. There was evidence of this in 1897. The whole comparative manure area was rested for a season and on all the plots as well as on the pathways between plots a catch crop of green fodder was grown. On almost all plots the growth was very luxuriant, and the exact limits of each plot could be seen at a glance. The pathways between the plots grew in every instance only a middling crop. These pathways received practically the same tillage as the plots during the previous three years, but got no manure. The mere fact that so much nitrogen is given in the manure and so little is taken up by the crop suggests the idea that it would be far more economical to apply a smaller dressing of manure in repeated top dressings. This is practicable as regards concentrated manures like oil cakes, but is hardly practicable in the case of bulky manures like farm-yard manure and poudrette, &c., because of the difficulty of spreading evenly a bulky manure on a crop which has grown so that it completely shades the ground. The whole question requires thorough elucidation by experiment.

Method of
applying
manure and
subsequent
tillage.



18. Poudrette or farm-yard manure should be deposited in heaps regularly over the field, three or four heaps from one cart-load. The manure should be evenly and carefully spread. The land should now be ridged up with the plough into ridges 24 to 28 inches apart, the furrows being as deep as possible. The plough should then be run across the line of ridges to form parallel water channels 10 feet apart. Finally the field should be laid out into beds 10 feet square. The *bándh* round each water compartment should be raised by soil moved with the hand hoe from the furrows and by removing about 9 inches from the ends of each ridge inside any particular water compartment. Each compartment when complete contains four short ridges and five furrows as shown in the marginal diagram. The thick lines indicate the crests of the ridges.

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19. The planting operation proceeds very methodically. One acre of good cane provides sets sufficient for 11 or 12 acres. Ratoon cane usually provides the best sets, because the joints or nodes are close together. Usually the sets got from the top end of the cane are longer than those from the base, because the nodes of the former are farthest apart. That portion of the cane nearest the green top is considered suitable for planting. Some authorities consider the "tops" better for sets than any portion of the mature cane. There is no doubt that the tops when used as sets root quickly and the central shoot springs into growth very quickly and the germination is therefore very regular and satisfactory, but it has yet to be proved whether the resulting crop is better or worse than from ordinary sets planted in the ordinary way. Each set from the top end would be quite a foot long; whereas from ratoon cane the sets would not be more than 8 inches long on an average. 16,000 to 18,000 sets are required per acre in the Poona District. The sets are carried in head-loads to the field to be planted and laid along the ridges and on the *bándhs* of each water compartment. Water is turned into each bed in turn. When the water has partially soaked into the soil and softened it, the planter begins to lay the sets carefully in the bottom of the furrows trampling each set down 3 or 4 inches into the soft mud. The distance between sets is about 4 inches. Planting in the Poona District should be done if possible in February and certainly finished before the middle of March.

Application of concentrated manure.

20. If a concentrated manure is used, it should be applied after the beds are formed and before the sets are planted. It should be broadcasted by hand along the furrows and mixed with the soil by stirring lightly with a small pick or hand hoe.

Weeding.

21. A month after planting, the land should be carefully weeded with a *khurpa* or hand-spud. This tool is like a small sickle, both the outer and inner sides are ground or bevelled so that there are two cutting edges. The weeding should be repeated as often as is necessary. Usually four weedings are required. The *khurpa* is used not only to remove weeds but to move the surface soil. This is beneficial as the soil cakes on the surface after irrigation.

22. In June or July new beds are formed. The soil is dug and levelled and all weeds removed. A second dressing of manure may now be conveniently given. The canes originally planted in the furrows are earthed up with a hand hoe. This leaves a furrow between the rows of cane. These furrows serve as water-courses for water, admitted into each water compartment. The earthing up gives support to the cane so that it does not readily lodge even if a very heavy crop.

Making new beds in June or July.

23. Lodging is harmful, in as much as Dr. LEATHER has proved by analysis, that lodged cane contains a smaller percentage of crystallizable sugar than up-right cane. A sprinkling of *Sherri* (*Sesbania ægyptiaca*) or of castors in the crop and particularly along the water channels and

Lodging of cane causes loss of sugar. How to prevent lodging.

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borders gives support to the cane so that it does not readily lodge. Moreover, the *Shevri* and castors yield good returns. Both plants grow to a height of some 15 to 20 feet in a year. The young *Shevri* branches are pruned and sold as fodder for milk goats and the trees give poles useful for roofing huts. The value of the produce from castors is also considerable. Sometimes to prevent lodging, cane is tied up. This operation must be carefully done to be effective. Canes from different roots should be tied, about six canes together loosely but securely with a band of dead leaves about 4 feet from the ground.

**raiding and
wrapping.**

24. Cane is trashed by removing all dead side leaves; thus air gets freer access and no doubt the crop is benefited. Wrapping the cane in its own dry side leaves is a costly operation which, however, probably pays where jackals and rats are very destructive. Jackals will not do much harm to wrapped cane if there is unwrapped cane conveniently near.

**Irrigation
and amount
of water
actually given
for cane in
Poona Dis-
trict.**

25. After July or August in the Poona District cane requires no further attention except watching and careful watering. Irregular irrigation spoils the quality of the crop. It causes in soft juicy varieties splitting of the cane. The land is first flooded as the sets are planted and thereafter two or three times at short intervals to encourage the eyes to shoot. Subsequently 8 to 10 days may elapse between waterings; the shorter interval in the hot weather, the longer in the cold season. During breaks in the rains irrigation is required. The rainfall in the Poona District averages about 30 inches. I have found by actual measurement that sugarcane on an average gets during 12 months, in addition to the rainfall, irrigation water equal to 75 to 80 inches of rainfall, the crop being irrigated on an average 28 times in a year. Therefore the water given at each application was equivalent to $2\frac{1}{2}$ to 3 inches of rainfall or approximately 250 to 300 tons per acre. This is the quantity of water taken by an ordinary cultivator when he supplies himself from the canal. He would use less, probably to the advantage of his crop, if he drew the water from a well. We proved by actual experiment that more frequent lighter irrigation was preferable, i.e., that a considerably heavier crop was got by irrigating 34 times during the year, giving in all water equivalent to 50 inches of rainfall in addition to the rainfall (30 inches). The extent of irrigation necessarily depends upon various circumstances. The thin hard bamboo varieties require much less water than the soft thick succulent kinds. In deep moisture-holding black or clay soils the interval between waterings in the fair season may be much longer than on soils of lighter description. In the sandy and light loam soils of Northern Gujarát, irrigation for soft cane is necessary every 5th or 6th in the hot weather and every 7th or 8th day in the cold weather. In contrast to this it may be noted that soft varieties, grown in the Surat District on embanked rice fields with deep soil retentive of moisture, if planted deep with a plough in moist soil in November, do not need water until the

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following February. Cane planted after November requires to be watered in January to assist germination. Six waterings are given between February and the end of May. No artificial irrigation is required in the monsoon, but two or three waterings may be given after the rains in September-October.

26. Sugarcane makes slow growth during the first three months and it is quite common to grow with it subordinate crops, which ripen quickly. Maize, *Guvár* (**Cyamopsis psoraliodes**), onions, cucumbers, melons and tobacco are so grown. The maize cobs are plucked before being ripe and used as a green vegetable. The stalks are cut green and therefore give much better fodder than that from a dead ripe crop. The *guvár* beans are also plucked green whilst the uprooted stalks are broken up by hand and with the leaves are left on the ground to serve as a green manure. Onions are grown from transplanted seedlings raised in a separate seed-bed. They may reach maturity before the sugarcane quite shades the ground. If they do not, it does not matter as they are quite marketable at almost any stage of growth. Melons and cucumbers are grown from seed planted here and there, but more particularly on the headlands. These plants make very rapid growth in a heavily manured sugarcane field. Tobacco is planted along the water-courses and on the *bíndhs* of the water compartments and takes about five months to come to maturity after the seedlings are transplanted. If the sugarcane, meantime, makes rapid progress the tobacco will not come to much.

Subordinate
crops.

DISEASES OF SUGARCANE.

27. On sandy or light soil white ants are often very destructive. They attack the sets, the roots and the stems. Castor-cake used as manure is believed to keep white ants away. In Gujarát a common practice is to put a quantity of pounded castor-cake in a reservoir near a well. The irrigation water is made to flow through this reservoir. The cake gets soft and pulpy and an extract is carried by the irrigation water to the crop. In a few days the manurial value of the cake becomes exhausted and the spent cake is removed and thrown in the common manure pit. It is quite probable that this is an effective method of using castor-cake or perhaps any other cake as manure and the extract has fully as much effect in keeping white ants away as cake directly applied. It is questionable whether the cake becomes really exhausted by a few days' steeping, yet it may be so, for a somewhat analogous effect is well known by gardeners, *viz.*, that if fresh cowdung or horse-dung is steeped in water for several days, a liquid manure is produced which is extremely effective for roses and other plants in pots.

White ants
destructive.
Castor-cake
as a preventive.

28. Salt is also used as a preventive for white ants. The method of application is simple. It is tied in a cloth or sack mixed with assafoetida and hung at the head of the water channel and gradually gets dissolved in flowing water.

Salt for white
ants.

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DISEASES.

Aphides on
sugarcane.

29. Sugarcane is subject to several blights, known by various vernacular names, but all due to Aphides which increase rapidly especially in cloudy weather. Their presence is always accompanied by sticky matter on the leaves. These insects feed on the juices of the plant and thus exhaust the vigour of the cane. Insecticide spray applications are the only effective remedies. An easily prepared insecticide application would consist of 2 lbs. soap boiled in one gallon of water; add 2 gallons kerosine; churn or agitate the mixture until an emulsion forms; dilute with 15 to 25 gallons of water and apply to the affected foliage with a spraying machine.

Scale insect.

30. A species of scale insect is common and when it exists to any extent, does considerable harm. An observant cultivator will detect the pest early. All affected leaves should be removed, and burnt, and the pest is thus at once checked.

Sugar borer.

31. The sugar borer, *Diatraea Saccharalis*, (vern. *Gabra*) often does an immense amount of harm, and yet damage by this insect can be very easily checked, if proper measures are taken in time. The pest usually makes its appearance when the cane has fairly germinated, and the first indication, in the young shoots, is the withering of the uppermost central leaves. The middle or leading shoot can be easily pulled out from its envelope of leaves, and the core of the stalk is found quite rotten with an offensive smell. A number of small white grubs are always present, and in large numbers if there is much rottenness. These are not the cause of disease, but harmless larvæ of small black or brownish flies, which follow the borer. The true cause of the mischief, the larvæ of the sugar borer, is seldom found. The round hole, by which it entered, may be seen, but when there is much rottenness at the core, the borer has probably gone to another cane. If, when the first sign of withering is seen, the affected cane or shoot is cut close to the ground and slit up, one or more borers will be found in a tunnel made in the solid cane. Professor T. H. MIDDLETON, late of Baroda College, describes the sugar borer thus:—

"The full-grown caterpillar is about $\frac{4}{5}$ " long and $\frac{1}{4}$ " diameter. The body is yellowish-white with purple lines along the back. The head in the young is almost black, is brown in half-grown, and light brown in full-grown specimens. The sides of the body segments and the tail are furnished with short side bristles. Young and half-grown specimens are very active, but the old caterpillars are slow in their movements. The pupa is about $\frac{1}{2}$ " long, is blunted and of brownish colour at the anterior end, pointed and golden yellow at the posterior. The moth emerges from the pupa after seven days. It is grey coloured $\frac{3}{4}$ " long with $\frac{1}{4}$ " spread of wings. The first pair of wings is grey with fringed margins and black spots just inside the margin. The second pair is silvery. The abdomen is plump silver grey, and extends $\frac{1}{8}$ " beyond the wings. The moth is very sluggish in captivity and there is reason to believe that it does not move far from one locality when free."

Remedies for
sugar borer.

32. Remedies.—Cut close to the ground, and burn all affected shoots as soon as withering of the central leaves is noticed. The caterpillars are almost certain to be inside the cane at this time. If no remedial treatment is adopted the insects will run through many generations in a single season, and the crop will be greatly damaged; not only so, but the canes will be so infected that they cannot be safely used for sets for re-planting. The sugarborer also attacks *jowâr* and maize, but the moth is so sluggish

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A root
parasite.

in its movements that a field cleared of the pest as described above is not likely to be re-infected by insects coming from a distance.

33. Sugarcane like *jowar* and some other cereals is subject to attack by a vegetable or root parasite *Striga lutea* (*Tarli* Deccan, *Agio* Gujarát). The *Agio* of Gujarát appears to have fleshier leaves and stems than the *Tarli* of the Deccan, but they are clearly botanically very much the same if not identical. The parasite is found thriving close to the stems of cane, or of *jowar*. Its fibrous roots entwine round the roots of the crops named, and check their growth. The parasite grows rapidly, and the only way to save the crop is by constant weeding. *Agio* belongs to the natural order *Scrophulariæ*. It is found abundantly in grass *kurans* (pasture lands), and therefrom doubtless finds its way to arable land in the dung of animals. It survives without a host; but it can be carried in the host plant. In proof of this, I noticed one particular variety of cane, on the Surat Farm this year (1897), badly affected at an early stage of growth. Other varieties in other adjacent beds were not affected. If once established in highly manured sugarcane land, it thrives amazingly. In irrigated land it flowers and seeds at all seasons, and is, therefore, extremely difficult to eradicate.

Smut.

34. Sugarcane is subject to smut which is probably caused by the same species of *Ustilago* as causes the smut, so common in ordinary cereals. Apparently the disease only attacks the flowering rachis, and if it is really confined to these parts, it cannot do much damage to the crop, as sugarcane does not commonly produce flowers. It is unusual to find varieties, which have long been grown in India producing flowers; but varieties of vigorous habit of growth, which have recently been introduced into India, generally flower freely. I have only observed smut in the thin hard or bamboo varieties, and its effect is most curious. At the Poona Farm cane propagated from sets became affected with smut when three months planted. The affected flowering stalks were premature growths. In the ordinary course no inflorescence would have been produced for 10 to 12 months after plantation. The presence of disease spores apparently forced the premature growth of the inflorescence in order to provide a suitable host for the disease. The source of infection was obscure; the crop from which the cane sets were got had not been observed to have been affected. Sets from this variety, as well as sets from many other varieties, all grown at Poona, were sent to the Surat Farm, and also planted at Poona. At both farms this particular variety, and no other variety became affected. It might be urged that the sets, or their eye-buds, were obviously the source of contagion. The practice of pickling cane sets, in the same way as seed grain, as a preventative is obviously inapplicable; and the only remedy appears to be to remove and burn all affected shoots.

HARVESTING.

35. It is difficult to judge accurately by the eye when sugarcane is ripe. Frequently a cane-grower tests the ripeness of his crop by a trial boiling. If so many measures of juice give a satisfactory weight of *Gul*,

Tests of
ripeness.

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harvesting operations are proceeded with, otherwise the work is postponed for a fortnight or longer. A cane crop usually gets a yellow appearance as it ripens, but this colour may also be caused by irregular or deficient irrigation; and a crop that is in want of manure, or is otherwise badly cultivated, gets yellow long before it is ripe. In a well grown crop, if the side leaves are all dead, and if the eye-buds almost to the top of the cane are fully developed and firm, the cane is probably quite ripe. I do not think any loss is occasioned if the crop is allowed to stand for a short time after it is dead ripe, provided (a) it is not lodged, (b) that the eye-buds have not begun to freely grow, (c) that irrigation is regularly given. If the cane is watered a few days before it is harvested, the amount of sap is increased, so that more juice is expressed by the mill, and, therefore, more sugar obtained.

**Method of
harvesting.**

36. If it is intended to grow a ratoon crop, the cane should be cut with a sharp sickle at a height of 1 to 2 inches above ground. If no ratoon crop is to be taken, the cane should be uprooted, each cane being separately removed from the root stock by a sharp jerk. Uprooting is easily done as the roots have not a firm hold of the soil. Cane should be reaped, or uprooted, in the early morning whilst the leaves are yet wet with dew. Later in the day, the heads and arms of the workmen would be cut by the sharp edges of the dry leaves. A second man follows each reaper, and with a sickle strips the dry side leaves from each cane. With practice any ordinary cooly can acquire the knack of doing this expeditiously. The upper green leaves, which are useful as fodder, are not removed in the field. The dry side leaves are left as a litter over the surface of the field. Subsequently they are collected, and tied into huge head-loads, and carried to the *Gurhál* to be used as fuel in the *Gul*-boiling process, or as thatch for huts &c. The cane is tied into bundles, and carried in head-loads to the *Gurhál*, or if the distance is far, in carts.

**Harvesting
and *Gul*-making
done by
contract.**

37. The whole operation of harvesting and *Gul*-making is undertaken in the Poona District at contract rates. The owner of the field supplies a cane-crushing mill or mills, and all *Gul*-making apparatus, and also lubricating oil. The contracting workmen find four pairs of work-cattle for each mill. The cattle are worked in relays, two pairs at a time. Eleven workmen are attached to each mill. Unless each man has an interest in the contract, more are required. They cut, and carry cane sufficient to give juice for four boilings in a working day (the work being partly done at night). Each boiling requires 22 *gharas* (earthen pots) of juice. The juice required to fill a *ghara* weighs approximately 42 lbs. One boiling of 22 *gharas* produces one *Dhep* or sugar-loaf of crude sugar (*Gul*), and each *Dhep* from the Poona *Pundia* variety of cane weighs from 148 to 160 lbs. according to the quality of the juice and the luxuriance of the crop. The contract rate for four *Dheps* per day is, generally, Rs. 5. Sometimes it is as low as Rs. 4. The contracting workmen get as much cane for raw eating as they like. Their women and children surreptitiously

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RUM:
Sugar.

take, or at any rate get a good deal, and every passing wandering beggar expects a good big piece of cane. The contracting workmen get the green tops to feed their cattle. Ordinarily a good many more cattle than the work-cattle are actually fed. The extras, *i.e.* the cane for raw eating, and the green tops for cattle feeding vary in value in different seasons. Therefore the contract rate also varies.

CRUSHING.

38. The most approved pattern of mill in use in the Bombay Presidency is a three iron-roller mill made by several firms in Poona. The mill is made in various sizes. The most common pattern costs Rs. 120, and has three rollers (height of rollers 18", diameter 11") ranged vertically between upper and lower cast-iron plates. The two side rollers revolve in sockets, placed on the upper and lower plates. The upper part of each roller is cut like a cog-wheel. The cogs of the two side rollers work into those of the middle roller. The draught bar is attached to the central roller, and this roller communicates the motion to the two outside rollers. The rollers are adjusted, in respect of closeness to each other, by long iron wedges, which when driven home at the upper and lower sockets, move the side rollers closer to the central roller. The shaft of the central roller passes through the upper plate. It is round in shape to a height of 6 inches or so above the plate. The rest of its length is square. On the upper square end of the shaft a rest for the draught pole is securely keyed. The draught pole is bolted to this rest, as shown in the subjoined diagram which shows the Poona three-roller mill at work.

CRUSHING.

The Poona
pattern of
cane-mill.

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CRUSHING.

The draught pole has, sometimes, at its centre an iron piece fashioned as



per marginal drawing. This iron piece is keyed to the squared part of the shaft of the central roller, so that the central roller gets direct motion from the draught pole, as it is turned by a pair of bullocks, attached at A, and another pair attached at B. When the mill is adjusted for work, the rollers should be perfectly vertical, and so close together, that it is hardly possible to see through between two adjacent rollers.

Cane crushing.

39. The cane is passed twice through the mill, first between the middle and one outside roller and back between the middle and the other outside roller. These operations go on, simultaneously, two men, one on either side of the rollers, being required, one feeding the whole cane, the other feeding the half-crushed cane. The draught pole is fixed on the shaft high enough to pass over the heads of these men as they sit in the usual native position at work. Two men or boys drive the work-cattle, and it is the duty of one or other of these to remove the crushed refuse as it collects, a basketful at a time, and throw it down evenly in an open space to dry, so that it can subsequently be used as fuel in the boiling process. A man prepares the canes for the mill by removing the green tops and cutting long canes into two shorter lengths for more convenient handling by the man that feeds the mill. Three or four pieces of canes are passed between the rollers simultaneously. Iron mills of the above pattern can, when properly adjusted, express up to 73 per cent. of juice from soft succulent varieties of cane. The quantity of juice expressed in a working day is approximately 3,700 lbs. If the cane is soft and succulent the working day is short, but long if the cane is hard and less juicy. The edge of the lower plate is turned up about $1\frac{1}{2}$ " in the shape of a rim. The juice as it is expressed, collects here and flows through an opening into a receiver placed underground. This receiver holds eleven *gharas*, so that it has to be twice emptied to supply juice sufficient for one boiling. The bottom plate of the mill and the top of the underground receiver are practically flush with the ground. Close-fitting loose boards are placed over the receiver. The man who feeds the half-crushed cane sits on these boards and notices that the receiver does not overflow with juice. The juice from the underground receiver is emptied into two iron drums placed

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near the evaporating pans. It should be strained through cloth or through a wire gauze sieve to remove impurities. When these drums are quite full the juice is emptied into the evaporating pan. The two drums just hold enough (920 lbs.) juice for one boiling.

40. Iron mills have taken the place of wooden mills in all parts of the Presidency. In Gujarāt and in Dhārwar only a few of the cane cultivators own iron mills. The use of these will extend as the advantages become known. Their advantages, both as regards economy in labour and effectiveness at work, cannot be questioned; still the old wooden mill is very much in evidence. A common belief prevails that the wooden mill gives purer juice which can be made into finer *Gul* than the ironmill; but this is mere fancy. The true reason why the wooden mill keeps in favour is that it is made locally and the parts can be replaced or repaired as they go wrong. The mill costs Rs. 35 to 50. It is slow at work and constantly liable to accident, causing suspension of operations until the village carpenter arrives to repair it. The iron mill is an adaptation of the wooden mill. The latter has three wooden rollers about 3½ feet in length and 1 to 1½ foot in diameter. These are placed side by side in a strong wooden frame. The upper part of each cylinder is cut out in the form of a screw. The draught bar is attached to the central roller much in the same way as described for the iron mill. The middle roller is called the husband and the side rollers the wives. The male screw of the central roller fits into the female screws of the side rollers, and communicates motion to the side rollers. The cane has to be repeatedly passed between the rollers before all the juice is expressed. The mill, though clumsy and heavy to work, extracts the juice fairly well. A wooden mill in good working order extracts as much as 65 per cent. juice from soft succulent cane.

The old-fashion-
ed wooden
mill.

GUL-MAKING.

41. The evaporating pan in most general use is about 7 feet in diameter and 9" to 12" deep. It is made of stout sheet iron which in pieces of the required shape are rivetted together. The pan has four circular handles each about 4" in diameter, welded or fixed to the lip of the pan at equal distances apart. When it is necessary to place the pan on the furnace or remove it therefrom, two stout poles are passed each through a pair of opposite handles. Four or more men lift the pan and carry it steadily by means of these poles. Two pans are required, one is used for evaporating, the other as a cooler into which the hot *Gul* is emptied when boiling is complete.

The boiling
process.

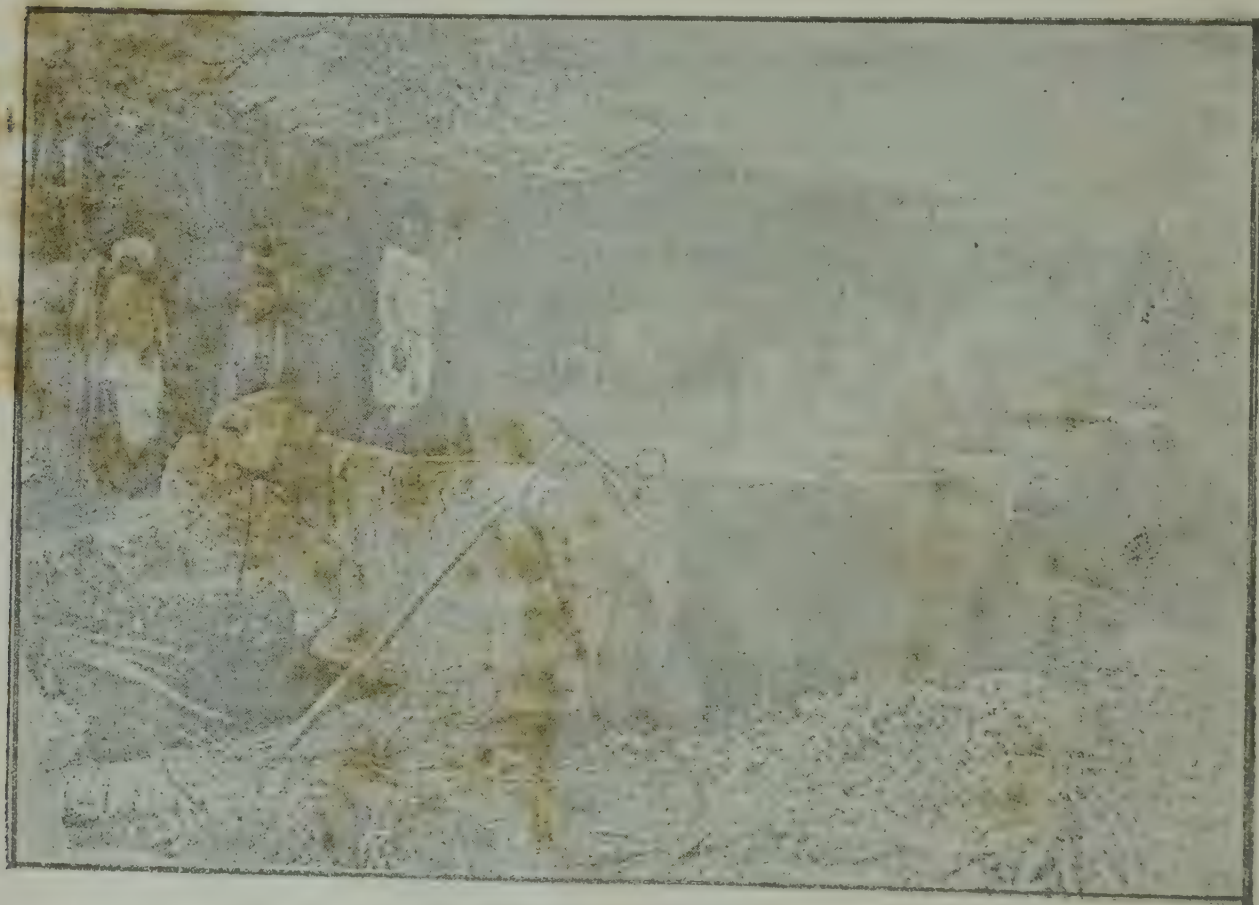
42. The oven or furnace is of simple construction. A trench is dug about 18 inches wide, 8 feet long, gradually getting deeper towards one end until a depth of some 5 feet is dug out. A circular excavation is now made at the deep end with a diameter of 4 to 5 feet. This circular chamber and the trench is the source whence the oven or furnace is provided with a draught of air and also provides room for

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the ashes. The ashes which collect one day are removed before work begins the following day. The furnace which is partly excavated and partly built up is of larger diameter than the ash chamber. It is nearly the same diameter as the evaporating pan, being about 6 inches less, so that the evaporating pan fits neatly on the top of the furnace. The ash chamber being of smaller diameter than the furnace, a ledge is left between the two on which corrugated iron sheets are laid to form the bottom of the furnace. There is a grating in the centre about a foot square. Ashes escape through this and the draught air is admitted. The furnace is built up with sun-dried bricks in a circular form inside to a height of about $3\frac{1}{2}$ or 4 feet. The brick work is banked up all round with earth. The front is built up square and a small opening is left about $20'' \times 14''$, through which the fire is fed with fuel as required. The lip of the oven is plastered smooth so that the evaporating pan fits accurately. The furnace is of large dimensions, because it is necessary to maintain a regular moderate heat during the boiling process. The diagram below shows two furnaces side by side.

Preparing
the pan.

43. The pan is prepared before use by rubbing it well inside with leaves of the castor oil plant and then with a paste of *Udid* (*Phaseolus radiatus*) flour and *Til* (*Sesamum indicum*) oil, the object being to prevent the *Gul* burning and sticking to the pan. The *udid* flour pre-

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serves the oil so that the pan only requires re-coating occasionally. It is not required oftener than every two or three days.

44. The sugar boilers are professionals in the Poona District and pretend that special knowledge is required to make good *Gul*. There is no mystery in the art further than that a regular heat should be maintained and that all impurities should be skimmed off during boiling.

45. The dry side leaves and the dry refuse of crushed cane usually provide sufficient fuel, especially so in the case of a good crop. If extra fuel is required, the husk of safflower or the stalks of *Tur* (*Cajanus indicus*) or of cotton or light brush-wood are commonly used.

46. The fuel should be of such kind that the fire can be continuously fed by small quantities thrown into the furnace at a time.

47. As soon as the juice begins to boil, impurities rise to the surface in the form of a scum. This should be removed. Skimming is done with a long-handled wicker work ladle which allows the pure juice to drain away but retains the thick scum. This ladle is also used to agitate the syrup vigorously to prevent boiling over, when the fire is too hasty.

48. The impurities are most effectively removed if a mucilagenous extract from the *Bhendi* (*Hibiscus esculentus*) plant is mixed with the juice when boiling begins or at a later stage.

49. It usually takes about 2½ hours to boil a panful of juice to the proper consistence. When evaporation is nearly complete, the mass acquires the yellow-brown colour of *Gul*. It heaves and bubbles rather than boils and should be kept in constant movement by a wooden hoe moved backwards and forwards in all directions. The syrup is boiled sufficiently when a little put in cold water hardens quickly. The pan is then removed from the furnace. A blessing is invoked and the contents emptied into the cooling pan. Here the *Gul* is stirred repeatedly with a wooden hoe as it cools. When it is cool enough it is put before it hardens by means of a wooden spatula into a cloth which lines a cylindrical hole in the ground. Here it sets into a hard block or *Dhep*. It is removed next day and is ready for sale. If the blocks are pale in colour and hard the *Gul* is considered of good quality.

50. In January of this year (1898) a comparative trial was arranged for, in the Dhárwár District by the Agricultural Department, to demonstrate the capabilities of the Poona three-roller iron mill, in comparison with the time-honoured wooden mill, and with a double squeeze three-roller iron mill made at Bellary (Madras), which has recently come more or less into use in the Dhárwár District. The opportunity was also taken to demonstrate the Poona method of sugar boiling.

GUL-MAKING.

Professional
boilers.

Fuel.

Feeding the
fire.

Skimming.

Impurities
removed.

The boiling
process.

Comparative
trial with
different
mills.

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WITH DIFFERENT
MILLS.

I believe that successful demonstrations of this kind are impressed much more forcibly and beneficially on the minds of ordinary agriculturists if conducted by native officers, provided the men so employed have tact, shrewdness, and thorough practical knowledge of the work in hand. The overseer of the stock farm and sugarcane experiments at Mánjri, who is a Kunbi or agriculturist by caste, was sent to conduct the trial. With him was also sent a professional sugar-boiler of the Poona District, also a man accustomed in the Poona District to feed fuel to the fire during the boiling process. These men could, with their own hands, build a fire-place and other necessary construction of a *Gurhál* according to the Poona plan. The work referred to, and the boiling process require a certain degree of expertness which is very easy to demonstrate by actual practice, but which would be difficult to describe by tongue or pen.

A three-roller mill and all the apparatus necessary for a complete outfit for sugar-boiling were sent to Hirekerur, Dhárwár District. The cultivation of sugarcane is very extensive in this place. The apparatus had been in use for two seasons at Mánjri, and the success of the trial may fairly be gauged by the fact that cane cultivators offered to buy the mill and all the apparatus at cost price. In consultation with the Collector, it was decided not to press for freight charges from Poona, because with the exception of the mill (the freight charges on which would be trifling) the rest of the apparatus can be locally made, now that a proper pattern is available. The freight charges on all the apparatus amounted to Rs. 70, whilst those on the mill only would be under Rs. 20.

The tabulated statements which are given below show that the Poona mill, doing $\frac{3}{4}$ ths of the work in a day, which it ordinarily does in the Poona District, is not only a labour-saving machine as compared with the Bellary mill and the old-fashioned wooden mill, but at work is considerably more effective. The amount of juice left unexpressed by the Bellary mill which the Poona mill could have expressed, represents a loss of one pound of *Gul* per every 100 lbs. of cane crushed, and in the case of the wooden mill $2\frac{1}{2}$ lbs. of *Gul* per 100 lbs. of cane. Forty tons per acre of cane is not a heavy crop, and not more than average for the Poona District, and we may take it that the Bellary mill as worked at Hirekerur left unexpressed juice equivalent to 800 lbs. *Gul* per acre of good crop, whilst the wooden mill probably left 2,000 lbs. *Gul* per acre of good crop. The cost of the Poona mill could thus easily be recovered in a single season, owing to its more effective work. The question may be raised whether the respective mills were properly adjusted for effective work. The Poona mill certainly was, because the percentage of juice expressed is the percentage ordinarily obtained from good cane. We may assume that the cultivators had the other mills adjusted for work to the best of their knowledge. The manufacturer of the Bellary mill possibly, if he had been present, could have adjusted it better. The officer in charge

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was fully instructed regarding the manner in which the trials should be conducted, and had express orders to prevent any attempts to work the cattle in any of the mills beyond their ordinary pace, whilst the trials were in progress, and generally to see that the trials were complete in every respect.

Comparative statement showing the work of the three sugarcane mills tried at Hirekerur (Dhárwár).

Name of the Mill.	Weight of Cane.	Weight of Juice.	Weight of Gul.	Percent- age of juice to Cane.	Percent- age of Gul to Cane.	Value of Gul pro- duced in a day.	Loss of juice in a day taking Poona mill as the stand- ard.	Value of Gul or juice thus lost per day.
	lbs.	lbs.	lbs. oz.	lbs.	lbs.	Rs. a. p.	lbs.	Rs. a. p.
Dhárwár wooden mill with three rollers.	2,343	1,335	299 0	56.97	*12.76	18 0 2	258 (57.7 Gul).	3 7 7
Bellary iron mill with three rollers.	2,187	1,395	313 8	63.79	*14.33	18 14 2	92 (20.6 Gul).	1 3 10
Poona iron mill with three rollers.	3,882	2,640	528 0	68.00	†13.60	37 2 11	...	...

The cost of labour for each mill per day for cutting, carrying and crushing cane and sugar-boiling is shown below, also other details (labour being charged at ordinary hiring rates).

Name of the Mill.	Weight of Cane crushed.	Time occupied in crushing.	Weight of Juice obtained.	Weight of Gul obtained.	Number of boilings per day.	Labour for cutting, carrying, crushing, and boiling, &c.			Remarks.
						Work people.	Bullocks.	Amount.	
	lbs.	H. M.	lbs.	lbs. oz.				Rs. a. p.	
Dhárwár wooden mill with three rollers.	2,343	9 50	1,335	299 0	3	5 men 2 boys	4	2 8 0	Man 4 annas per day. Boy 2 annas per day. Bullock 1 annas per day.
Bellary iron mill with three rollers.	2,187	9 21	1,395	313 8	3	5 men 1 boy	4	2 6 0	
Poona iron mill with three rollers.	3,882	8 33	2,640	528 0	3	9 men 2 boys	8	†1 8 0	

The first mill is a wooden mill with three vertical rollers fixed side by side in a wooden frame, similar in construction to the mill described in paragraph 40. To work this mill one man, one lad, one boy, and four bullocks in relays two at a time, are required; the man to feed the mill,

* Scum not removed during boiling process. † Scum removed during boiling process.

‡ The work-people had not got experts at the work like Poona cultivators, and the work done in a day with the Poona mill at Hirekerur was about $\frac{2}{3}$ ths of that usually done by contract work near Poona. Four boilings per working day are always done at Poona with manual and bullock labour equal to that used at Hirekerur, contract wages being, for bullocks and men, Rs. 5 per day.

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the lad to pass the cane a second time through the mill and the boy to drive the bullocks.

The following are the measurements of the different parts of the mill :—

Diameter of the middle roller	...	...	1' 6"
Do. of one side roller	...	...	1' 3"
Do. of the other side roller	...	...	1' 1"
Length of each roller	...	...	3' 6"
Length of the beam (draft pole)	...	...	8' 4"

This mill at ordinary speed makes 162 revolutions per hour.

The second mill is a three roller iron mill. Two of the rollers are of the same size, and the third is smaller in diameter. They are set vertically in a triangle. This mill is very useful for small sugarcane areas. The cane, as it passes through, is double squeezed. One man only, therefore, is required to feed the mill. A boy or lad can drive the two bullocks. Four bullocks are required for a full day's work, in relays, two at a time.

The measurements of the different parts of the mill are as under :—

Diameter of the larger roller	...	0' 8"
Do. smaller roller	...	0' 4½"
Length of the roller	...	0' 10"
Do. beam (draft pole)	...	8' 0"

This mill at ordinary speed made 166 revolutions per hour.

The Poona mill described in paragraph 38 costs Rs. 120, the Bellary mill Rs. 125, and the wooden mill any price between Rs. 35 and Rs. 50, depending upon size &c.

The pan commonly used in the district has a diameter of 5' 2" at the top and is 11" deep at the centre and is saucer-shaped.

It is a common practice in the Dhárwár District to mix about 4 ozs. of slaked lime to a pan of 465 lbs. of juice immediately after it is poured in for boiling. People believe that the jagri thus made is harder. The scum, although it rises during boiling, is not skimmed off, and so dark-coloured jagri is produced. When the comparative trials were commenced people visited every day in numbers, and always asked why no lime was used. They noticed the bright colour of the jagri made by the Poona method, and thought it was due to the non-admixture of lime with the juice, whereas it was really due to the removal of the scum by skimming. To prove that the reason assigned by the people was wrong about 2 ozs. of lime was mixed to a pan and the jagri was in no way discoloured.* Then the people began to say "there is much loss in throwing away the

* If the question of discolour was the one at issue, then for fair comparison 8 ozs. for a full boiling of the Poona pan ought to have been used, and that amount would probably have discoloured the jagri. Lime sufficient to nearly neutralize the acidity of the juice only should be added. If used in excess of this, Dr. Leather has proved that it does discolour the jagri. The actual effect of adding lime in proper quantity is to reduce the percentage of molasses in the *Gul* and thus make it harder so that it will keep better.

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seum." An experiment was therefore made at a cultivator's *Gruhal* with the following results:—

Boiling.	Cane crushed.	Juice obtained.	Jagri obtained.	Percentage of Juice to Cane.	Value of Jagri per Rupee.	Value of Jagri.
	lbs.	lbs.	lbs. oz.		lbs.	Rs. a. p.
Seum not removed.	729	465	104 8	14.4	16.6	6 4 3
Seum removed ...	729	465	97 8	13.3	14.2	6 13 2

The above statement shows a loss of 7 lbs. of jagri when seum was removed. But this was made good by the higher rate obtained when sold. The people were satisfied, but I am not at all sure that quality is always appreciated. In some parts of the Presidency neither the whole-sale buyer nor the consumer pays much attention to quality. In parts of Gujarát no skimming is done and there, bright well prepared Poona jagri is objected to because it lacks flavour.

The only other point on which the people argued was, as regards the hardness of the respective blocks of jagri, and which would keep longest during the monsoon. The question was left in abeyance as it could not be settled, offhand, like other objections.

In Dhárwár jagri is not solidified into blocks as in Poona. As soon as the pan is ready it is removed from the fire, and stirred for a minute or so, and emptied directly into a *pack* (pit) which is made in the ground, 3 feet long, 2 feet 3 inches wide, and 4 inches deep. The *pack* or pit is sided with planks. The next day, the jagri in the *pack* has set hard, and is cut into 12 pieces each 9" square, and weighing from 5 to 7 lbs. While cutting the *pack*, there is generally about 4 or 5 lbs. of broken jagri which the owner keeps for home use. The Dhárwár cultivator shows poor ingenuity in solidifying his *Gul*. The Poona method described in paragraph 49 is much better; so also is the Madras plan of using a wooden mould divisioned into cells; but the Gujarát plan of storing in earthenware pots is best of all.

The dry leaves of sugarcane are not used for boiling jagri. They are sold for thatching. Firewood and sugarcane refuse are used for boiling.

In Dhárwár, there is not a special man to attend to the boiling as at Poona. The man that feeds the fire also looks after the boiling. The juice for one boiling weighs about 465 lbs., just about half the quantity usually boiled in the Poona boiling pan.

51. In the Poona District the *Dheps* are sold by the *Palla* of 120 *sers* or 240 lbs. By custom 246 lbs. go to the *Palla*. Generally throughout Gujarát it is customary to put *Gul* into earthenware pots. When sold a deduction of 5 *sers* per maund or 12½ per cent. is allowed

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gul.

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on account of the pots; but usually the actual weight of pots exceeds this allowance. There is a decided advantage in storing *Gul* in this manner, because if soft there will be no loss of treacle by drainage. Moreover, the *Gul* can easily be protected from flies and other insects. When sold by retail one side of the pot is broken off and the *Gul* is easily removed in small quantities. In Khándesh the potters who provide the earthen pots claim the crushed cane (megass) as their perquisite. They extract by lixiviation a small amount of inferior *Gul* and use the residue for burning pots and bricks.

COMPARATIVE MANURING EXPERIMENTS AT THE MÁNJRI
EXPERIMENTAL STATION NEAR POONA.

Results of
two years'
experiments
recorded.

52. These experiments were begun in 1894-95, but the plots were not manured in that year in accordance with any definite standard and were, therefore, unequally manured. Moreover, after a year's experience it was found expedient to modify the original scheme considerably. The results which I shall record are those of 1895-96 and of 1896-97. The former crop was newly planted cane, the latter was a ratoon crop grown from the root stocks of the previous crop.

53. *Objects of the experiments.*—To test the comparative values of such manures as are within the reach and means of ordinary cultivators and when the effects of the various manures have been clearly demonstrated then to determine whether two or more of the manures used cannot be judiciously combined so as to secure economy.

In both years the various manures each contained 500 lbs. per acre of nitrogen. The percentages of other elements of value are known, and in years to come it may be found that marked differences between the crops of the various plots may be traced to the value of elements other than nitrogen. If this can be done the value of the experiments will be enhanced and information be gained which will indicate how two or more manures should be mixed to give the most paying results.

Several edible
oil-cakes
tested as
manures in
comparison
with those
ordinarily
used.

54. The manures which the cultivators of the Poona District ordinarily use are poudrette, cattle-dung, fish manure from the Thána coast, castor cake and *Karanj* (*Pongamia glabra*) cake. In both years we have tested and will continue to test in comparison with the foregoing several edible cakes which are now used for feeding cattle in India or are largely exported. These cakes can be bought in Poona at a considerably cheaper rate per ton than the castor and *Karanj* cake now so extensively employed as manure. DR. LEATHER'S analysis shows that the edible cakes contain much higher percentages of nitrogen (the most valuable constituent of manures) than the manure cakes, and our tests indicate that these edible cakes can be employed with economy and success as manure. It has been suggested that the use of edible cake as manure is surely a wasteful practice. My answer to that is that it is surely a much more wasteful practice to feed milch and work cattle with cake and other concentrated food and permit the solid excrement to be burnt as fuel and the

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urine to be lost. If edible cake is used directly as manure, something is returned to the land which will help to maintain fertility. It might be urged that work and other cattle can only be kept in efficient condition if partially fed on cake or other concentrated food and, therefore, it becomes necessary to show that the increased production of cane through the use of edible cakes as manure more than compensates for the cost of stimulating food given to cattle. This is difficult to show in black and white. At the same time, the fact that an application of 3 tons per acre of edible cake is capable of producing as much as 12,000 lbs. of crude sugar per acre as food for men and 12,000 to 15,000 lbs. of green tops as fodder for cattle proves that edible cake is put to a good use when used as manure. I admit it would be put to a better use if fed to cattle provided the solid and liquid excrements are properly conserved and used as manure.

55. There is no definite relationship between the values of the manures as determined by chemical analyses and their commercial value. It is certain that the cane-growers of the Poona District, though much above the average in intelligence, fail to recognise the difference in manurial value of the manures they use.

No definite relationship between the commercial value of manures and their value according to chemical analysis.

56. The results of our comparative manure experiments are not only intended to prove which manures in given quantity are most effective for sugarcane, but also which manures are cheapest. It may be that when a particular manure is shown to be cheap its extended use will soon make it dear, but there will be an advantage to somebody.

57. Farm-yard manure and cattle-dung are charged at full local rates, but it is right to notice that these rates are four times as high as cattle-dung sells for in out-districts where irrigated crops are not grown. It will probably be found eventually that at out-district rates, cattle-dung will be proved much the most economical manure that a cultivator can use; because considering its chemical composition it is much the cheapest. The value for manure will vary with the food given to the cattle and the care with which it is preserved with litter and urine. Properly saved farm-yard manure will not, as our experiments indicate, be weight for weight as valuable as pure dung, but then the manure pit will be filled much more quickly with the former than the latter. The dung from poorly nourished animals is considered by ordinary cultivators just as good as that from those highly fed. Both descriptions are with equal readiness used as fuel. In almost all districts the value of cow-dung as fuel is as great or greater than its value as manure because wood is scant and dear. In the Poona District this is notoriously the case. Therefore it is not surprising that a cultivator of cane sells the dung of his cattle as fuel and buys poudrette, oil-cake, &c., for his crop.

Farm-yard manure probably the cheapest manure a cultivator can use.

58. Although the quantity of each manure applied in the *Comparative Manure Series* contained 500 lbs. of nitrogen, there were very great differences in outturn between the various plots. This was particularly noticeable on the new cane, not to such an extent with ratoon.

Quick-acting manures give the best results especially the case of new cane.

**SACCHARUM:
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EXPERI-
MENTS.**

Slow-acting
manures
caused uneven
germination.

Oil-cake made
in country
gháni
extremely
quick-acting.

Hydraulic
pressed cake
slow in action
for reasons
given.

Period of
growth.

Manures
applied partly
before plant-
ation, partly
as a top
dressing.

Ratoon cane owing to its greater root development is able to get nutriment from a slow-acting manure much more effectively than new cane does in the early stages of growth. At any rate the differences between the plots of new cane were, in a great measure, due to variation in the activity and effectiveness of the various manures. Ratoon cane springs into active and vigorous growth at once and at the early stage there was no appreciable difference between its various plots; but in the case of new cane it was clear that some of the manures acted far more actively than others. How far the action was due to the presence in the manures of elements other than nitrogen, can only be conjectured at this stage of the experiments. The practical fact remains that certain manures, *i. e.*, fish manure, poudrette and some oil-cakes had quicker action than other oil-cakes and much quicker action than cowdung or farm-yard manure.

59. On plots with slow-acting manures, germination was irregular and the young shoots which did grow were obviously starved and checked in growth. This check was never afterwards recovered.

60. Oil-cakes as made in Europe are generally considered to be slow in their action as manure. Oil-cakes as made in the ordinary country *gháni* are extremely quick in their action. In India oil-seed as ordinarily pressed is ground up into an impalpable powder as the oil is expressed. The oil-cake is consolidated during the process, but before it is applied as manure it is again powdered, and I have no doubt the minute particles of cake again disintegrate into impalpable powder when brought into contact with the moisture of the soil. It is easy to understand that a manure in such a fine state of division will very soon show its effects upon a crop. The method of preparing cake in Europe and in the hydraulic press mills in Bombay is quite different. The seed is crushed, but not into fine particles. The crushed seed is cooked or steamed. Thus the oil freely escapes from the oil cells. The cooking of the crushed seed would of necessity convert the albuminoids into a much more insoluble condition than that in which they exist naturally. The albuminoids contain nearly all the nitrogen of the seed, and it is reasonable to suppose that the nitrogen as it exists in hydraulic pressed oil-cake does not become available as plant food nearly so soon as that in oil-cake made in the ordinary country *gháni*.

61. The results of the comparative manure experiments which I tabulate below under Series A and Series B will be better understood from the above explanations.

62. The new cane was cut in $11\frac{1}{2}$ to 12 months after plantation. Those plots which germinated well and were dressed with quick-acting manure ripened soonest. The ratoon cane was cut 10 to $10\frac{1}{2}$ months after the previous crop was reaped.

63. In 1895-96, the manure was applied three-fifths before plantation in March and two-fifths in July. In 1896-97, the ratoon plots were manured with three-fifths of the application in May and two-fifths in July. It is not customary to give manure to a ratoon crop until it has made considerable growth.

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(James Mollison.)

SACCHA-
RUM:
Sugar.MANURING
EXPERI-
MENTS.

Comparative Manures, Series A, 1895-96 and 1896-97.

Plot Number.	Manure.	Year of Crop.	Manure per Acre.		Cost of Manure per Acre.		Weight of Cane stripped and topped per Acre.	Weight of Tops per Acre.	Weight of Gul per Acre.	Percentage of Gul to Cane.	REMARKS.
			Tons.	lbs.	Rs.	a.	lbs.	lbs.	lbs.		
2	Safflower cake.	1895-96. New cane.	3.3	500	169	6	95,555	12,520	12,320	12.8	Planted 1st April 1895, harvested 23rd to 27th March 1896. Germination very regular. Crop had throughout an extremely healthy appearance, the leaves until the crop ripened being of a rich dark-green colour. Irrigated 27 times.
		1896-97. Ratoon cane.	3.9	500	185	13	71,760	...	8,430	11.7	Harvested 15th, 16th January 1897. Crop looked vigorous and healthy throughout. Irrigated 16 times.
3	Bassia cake (Mhowra) Bassia latifolia.	1895-96. New cane.	8.6	500	323	9	72,410	12,980	7,725	10.6	The first application of Bassia cake had apparently a poisonous effect. Only a set here and there germinated, replanted and then germination was quite satisfactory. The top dressing of manure given in July showed no harmful results. The crop from the second planting made steady vigorous progress. It was not fully ripe when harvested. If left longer, the results of the next crop would be interfered with. Planted on 1st April 1895, replanted on 8th May 1895, harvested 23rd, 28th March 1896. Irrigated 27 times. The low percentage of Gul to cane indicates that the crop was not fully ripe.
		1896-97. Ratoon cane.	8.3	500	299	7	68,820	...	7,895	11.5	Harvested 15th January 1897, regular germination. Healthy growth throughout. Irrigated 16 times.
6	Cotton-seed cake.	1895-96. New cane.	7.1	500	316	0	83,200	14,925	10,280	12.3	The cake was got from a Bombay mill, which, however, has stopped the manufacture, because the percentage of oil got from Indian seed is small and does not pay. The crop had a very thriving appearance throughout. Planted 31st March 1895, harvested 28th to 31st March 1896. Irrigated 27 times.
		1896-97. Ratoon cane.	6.5	500	362	1	73,645	...	9,050	12.3	Crushed cotton-seed was substituted for cotton-seed cake, the latter not being obtainable. It is believed that in districts where cotton is grown, and where the seed is very cheap, it will probably be found an economical manure for sugarcane grown in the same districts. The dark-green colour of the leaves of the cane was conspicuous in comparison with some of the other plots of the series. Reaped 12th, 13th January 1897. Irrigated 16 times. The price paid for the cotton seed is much dearer in Poona than in cotton-growing districts.

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MENTS.

Plot Number.	Manure.	Year of Crop.	Manure per Acre.	Nitrogen per Acre.	Cost of Manure per Acre.	Weight of Cane stripped and topped per Acre.	Weight of Tops per Acre.	Weight of Gul per Acre.	Percentage of Gul to Cane.	REMARKS.
			Tons.	lbs.	Rs. a.	lbs.	lbs.	lbs.		
7	Fish manure.	1895-96. New cane.	2.9	500	188 12	97, 81	14,445	11,590	13.2	The evenness of germination and vigour of growth were nearly as conspicuous as in Plot 2. The manure must be ploughed in or dug in deeply; otherwise crows, jackals, dogs and pigs are attracted. Crop planted 31st March 1895, reaped 10th to 17th March 1896. Irrigated 26 times. The high percentage of Gul to cane is noticeable.
		1896-97. Ratoon cane.	2.7	500	164 7	76,845	...	9,050	11.7	Reaped 12th and 13th January 1897. Irrigated 17 times.
		1895-96. New cane.	5.9	500	303 10	80,770	13,010	9,820	12.1	Germination and tillering quite satisfactory, but the crop had not the thriving, vigorous appearance and healthy colour of the best plots in the series. Planted 31st March 1895, harvested 11th to 17th March 1896. Irrigated 26 times.
8	Castor cake.	1895-97. Ratoon cane.	6.2	500	292 11	79,490	...	9,780	12.3	This plot gave the best crop of the whole series. Harvested 11th and 12th January 1897. Irrigated 17 times.
		1895-96. New cane.	6.6	500	289 0	83,270	10,915	9,770	11.7	Very little difference in the appearance of this and the adjoining castor-cake plot. Planted 31st March 1895, harvested 12th and 17th March 1896. Irrigated 26 times.
9	Karanj cake (Pongamia glabra.)	1896-97. Ratoon cane.	5.3	500	203 7	70,600	...	8,445	12.0	Reaped 10th and 11th January 1897. Irrigated 16 times.
		1895-96. New cane.	22.3	500	150 8	80,720	11,455	10,455	12.9	Results conspicuously good as compared with some other manures. Our results and chemical analysis indicate that the manure is a cheap, if not the cheapest, source of nitrogen in India even at the Poona price, which is very high. This manure only obtainable at populous centres; costly to transport. Crop planted 30th March 1895, harvested 13th to 19th March 1896. Irrigated 26 times.
		1896-97. Ratoon cane.	20.1	500	179 13	55,405	...	7,410	13.4	The crop was somewhat disappointing. Germination was satisfactory, but the crop at no stage of growth had the thriving appearance of the previous year's crop. Harvested 8th and 9th January 1897. Irrigated 16 times.
12	Poudrette.									
13	Cattle dung from ordinary fed cattle.	1895-96. New cane.	25.1	500	160 0	60,490	12,220	7,510	12.4	The results compared with some other plots are poor. Heavy dressing of the same manure was given in the previous year to this plot also with poor results. The inference is that cattle dung is slow in its action. The germination was quite regular, but the crop had throughout a yellow unhealthy appearance. Planted 30th March 1895, harvested 20th and 21st March 1896. Irrigated 27 times.

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MENTS.

Plot Number.	Manure.	Year of Crop.	Manure per Acre.	Nitrogen per Acre.	Cost of Manure per Acre.	Weight of Cane stripped and topped per Acre.	Weight of Tops per Acre.	Weight of Gul per Acre.	Percentage of Gul to Cane.	REMARKS.
			Tons.	lbs.	Rs. a.	lbs.	lbs.	lbs.		
13	Cattle dung from ordinary fed cattle.	1896-97. Ratoon cane.	18.9	500	127 12	70,445	...	8,150	11.6	This plot gave much more satisfactory results under ratoon cane than in the previous year. Owing to the well-known lasting effect of cattle dung the crop probably benefited by the unexhausted residues of the same manure applied during the two previous years. Harvested 7th and 8th January 1897. Irrigated 15 times.
14	Cake-fed cattle manure mixed with urine and litter.	1895-96. New cane.	29.0	500	184 14	53,790	11,175	6,950	12.9	The remarks made against Plot 13 apply equally to this plot. Crop planted 30th March 1895, harvested 20th to 24th March 1896. Irrigated 27 times.
		1896-97. Ratoon cane.	25.09	500	142 12	62,205	...	7,870	12.6	Ratoon crop more satisfactory than the previous year's crop of new cane. It is, however, clear that there are more satisfactory manures for sugarcane than either farmyard manure or cattle dung. Crop harvested 7th January 1897. Irrigated 16 times.
		1895-96. New cane.	3.4	500	162 0	63,600	10,960	7,900	12.4	The cake used is a hydraulic pressed cake made in Bombay from coarsely ground steamed seed. For this reason the cake possibly acts slowly. The results are poor for a cake so rich in nitrogen, and compare unfavourably with the other oil cakes, which, however, were all made in the country <i>ghani</i> and, therefore, probably acted more quickly. Planted 30th March 1895, harvested 1st to 23rd March 1896. Irrigated 27 times.
15	Safflower and groundnut cake.	1896-97. Ratoon cane.	3 6	500	158 15	68,030	...	7,680	11.3	The crop looked fairly promising during the whole period of growth, but the outturn of Gul is rather disappointing. It may clearly be inferred that hydraulic pressed cake made from coarsely ground steamed seed is slow in action even though rich in nitrogen. Harvested 18th and 19th January 1897. Irrigated 16 times.

Comparative Manures, Series B, 1895-96 and 1896-97.

4 Bone meal	1895-96. New cane.	lbs. 3,520	130	116 0	32,145	8,875	3,905	12.1	A heavy application of bones (5 tons per acre) was given to this plot in the previous year with poor results. It might reasonably have been expected that the residue left would have benefited the crop of this year. There is nothing to indicate that such is the case. The action of bones is so slow that they cannot be economically used as manure for sugarcane. The crop had the appearance of being starved throughout its growth. Planted 1st April 1895; reaped 25th to 27th March 1896. Irrigated 27 times.
	1896-97. Ratoon cane.	3,343	130	122 14	30,900	...	3,705	11.9	The results this year with ratoon confirm the above remarks. Reaped 14th January 1897. Irrigated 16 times.

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MENTS.

Plot Number.	Manure.	Year of Crop.	Manure per Acre.	Nitrogen per Acre.	Cost of Manure per Acre.	Weight of Cane stripped and topped per Acre.	Weight of Tops per Acre.	Weight of Gul per Acre.	Percentage of Gul to Cane.	REMARKS.
			lbs.	lbs.	Rs. a.	lbs.	lbs.	lbs.		
5	Dissolved bones.	1895-96. New cane.	3,520 Bones dissolved in acid.	130	196 0	36,275	8,531	4,950	13.6	Manured with 6 tons per acre dissolved bones in previous year. Crop fair, but cost of such a heavy dressing of manure entirely prohibitive. This year manure made on farm. Acid of ordinary commercial strength used; 640 lbs. acid to 3,520 lbs. bone meal. The price of the manure is entirely prohibitive for ordinary cultivation in the Poona district. Planted 1st April 1895, harvested 27th and 28th March 1896. Irrigated 27 times.
		1896-97. Ratoon cane.	4,401 dissolved bones or 3,343 crushed bones dissolved in acid.	130	207 5	54,845	...	6,365	11.6	Better results but not good enough to pay considering the expensive dressing of manure. Reaped 13th and 14th January 1897. Irrigated 16 times.
10	Bone meal and crude nitre.	1895-96. New cane.	3,520 bone meal, 1,290 nitre.	250	264 0	41,000	10,075	5,015	12.2	One-fifth of the nitre was applied before plantation; the rest in four equal top dressings given in June, August, October and December. It was believed to be economical to apply the nitre in top-dressings, because being very soluble it is easily washed away in drainage if not taken up by the crop almost at once. The crop did not benefit to the extent that was expected and the cost of the manure exceeded the value of the crop. Planted 30th March 1895, harvested 30th and 31st March 1896. Irrigated 27 times.
		1896-97. Ratoon cane.	3,343 bone meal, 1,230 nitre.	250	255 0	50,385	...	4,900	9.7	Nitre applied in 5 top dressings at intervals as above. The cane only yielded 53.7 per cent. juice, whereas the average of all other manure plots was approximately 68 per cent. The percentage of Gul to cane is very low. I can offer no satisfactory explanation. Again, the cost of the manure about equals the value of the crop. Reaped 9th and 10th January 1897. Irrigated 15 times.
11	Dissolved bones and crude nitre.	1895-96. New cane.	3,520 bone meal dissolved and 1,290 nitre.	250	344 0	65,715	11,695	8,435	12.8	Nitre applied as in Plot 10 for similar reasons. It is clear that dissolving the bones makes the manure more effective, but the cost is entirely prohibitive. Crop planted 31st March 1895, reaped 29th to 31st March 1896. Irrigated 27 times.
		1896-97. Ratoon cane.	3,343 bone meal dissolved or 4,401 dissolved bones and 1,230 nitre.	250	344 6	62,905	...	7,845	12.7	Nitre applied as above. Crop reaped 8th and 9th January 1897. Irrigated 15 times.

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64. The estimated cost per acre of cultivating sugarcane by hired labour in the Poona District is as follows:—

	Rs.	a.
First ploughing in November; 4 team plough does an acre in 4 days; 1 ploughman and 2 boys or lads driving	...	10 0
Second and 3rd ploughing in December	...	12 0
Levelling with log harrow twice and breaking clods by hand implement	...	3 0
Manure; cartage and spreading 25 tons poudrette per acre	...	180 0
Ridging; ridges 24" apart; 3 team plough, 1 ploughman, 1 driver; 1 acre per day	...	2 8
Making water compartments; contract-rate	...	2 4
Value of sets, 18,000 per acre	...	50 0
Carrying sets to field; 1st watering and planting	...	5 0
Watering 32 times in a year; 1 man for five acres at Rs. 7½ per month	...	18 0
Hand-weeding; first weeding a month after planting and other three at intervals as required until June	...	12 0
Digging and making new beds in July	...	10 0
Water-rate (canal water)	...	40 0
Cost of constructing <i>gurrhál</i> ; Rs. 10 or Rs. 2 per acre	...	2 0
Hire of sugarcane mill and other apparatus; Re. 1 per day or Rs. 16 per acre	...	16 0
Harvesting and <i>Gul</i> -making at contract-rate of Rs. 5 per 600 lbs., say	...	85 0
Marketing <i>Gul</i> and commission to <i>Dalál</i> as at Poona, Crop, 40 <i>Pallas</i> of 246 lbs. per acre	...	39 0
		486 12

Value of crop; 40 *Pallas* at Rs. 14 per *Palla* (price varies in any season from Rs. 12 to 18) ... 560 0

65. In growing a ratoon crop the cost of preparatory tillage is trifling. No sets are required; less manure is required than for new cane. The crop requires less irrigation than new cane, and altogether the saving in the cost of cultivation as compared with new cane is Rs. 120 to Rs. 150 per acre. A ratoon crop which has thriven well yields as much *Gul* per acre as a fairly good crop of new cane. In paragraph 13, I have shown the actual cost of cultivation in an experimental plot at Mánjri at Rs. 325 per acre and value of produce at Rs. 447.

66. DR. LEATHER'S investigations into the chemistry of the sugarcane crop have been published in full detail in the *Agricultural Ledger* (*Medical and Chemical Series Nos. 1, 4, and 9*). The following is a succinct resumé of the work as published in paragraphs 114 to 128 of DR. LEATHER'S Final Report:—

Conf. Agricultural Ledgers Nos. 13 of 1895, 19 of 1896, and 3 of 1897.

"114. The investigations may now be conveniently referred to under the following heads:

- (1) The composition of the juice—(a) in cane which had been transferred to long distances; (b) in cane which had been grown with varying amounts of manure; (c) in cane which had become *lodged*; (d) in the top ends of the cane; (e) in different varieties of cane.
- (2) The relation between the amount of sugar in juice and its specific gravity.
- (3) The determination of the amount of inversion which takes place during the concentration of the juice.
- (4) The amount of sugar which becomes lost in the scum.
- (5) The composition of the raw sugar, *gur*, *gul*, and *ráb*.
- (6) The refining of sugar by means of the hand centrifugal separator.

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(7) The total amount of sugar in cane and the amount remaining in the crushed cane.

(8) The amount of phosphoric acid and nitrogen in the sugarcane crop.

"115. (1-a).—*The composition of the juice of cane which had been transferred to long distances.*—In the course of the experiments under reference, several varieties of cane have been transported to considerable distances. In 1894, two varieties were sent from the Mauritius to Poona, one a white and the other a red variety. They were grown at Poona with very liberal amounts of manure, and so far as appearances went, both crops were splendid. They were reputed to give a juice containing some 18 per cent. of sugar. But at Poona the juice of both has contained much less than this amount. In 1895, the juice of the white variety contained about 12 per cent. of cane-sugar and 1.4 of glucose; that of the red variety about 10 per cent. cane-sugar and 2 of glucose. In 1897, (the third crop) the corresponding figures were 14.71 per cent. cane-sugar and 0.99 of glucose in the juice of the white and 12.7 of cane-sugar and 1.5 of glucose in that of the red variety. Thus, although the juice is still poorer than it ought to be, a material improvement has manifested itself during the three years.

"A second example of this nature occurred in the case of the Poona *Pundia*, the variety commonly grown around Poona. This cane at Poona has been found to contain from 16 to 18 per cent. of total sugar. It was sent to Cawnpore and Dumraon in 1895, but the crops at both farms produced a juice containing only 14 per cent. of total sugar in the 1895-96 crop, and there was just about the same amount in the crop of 1896-97.

"Some further evidence was gained during the past season. A number of varieties, commonly grown in the Bombay Presidency, were collected in 1895 and grown at Poona in 1896. These crops were then analysed in the past cold weather. Immediately afterwards I visited villages in the neighbourhood of Belgaum and Dhárwár, and analysed some of these same varieties in their native place, and it was then found that in three cases the quality of the juice was much lower, in two instances it was higher, and in one it was the same at Poona as in the crops at Belgaum and Dhárwár. Thus the evidence at hand points to the conclusion that transference of cane from one country to another may cause a material alteration in the development of the plant generally resulting in depreciation of the juice. The evidence given by the Mauritius varieties, however, indicates that the cane will gradually assume a normal composition in the course of a few years.*

"116. (1-b).—*The composition of the juice of cane which has been grown with varying amounts of manure.*—One of the questions which naturally presented itself at the commencement of the experiments was, 'What effect has manuring on the quality of the juice of sugarcane?' The plots at Poona and at Cawnpore received in each case very varying amounts of manure, and the question appeared to be one which would be readily solved. Accordingly, one or more samples of the juice of the cane from each of the plots in question at these two farms was analysed during the harvest. The results at first obtained are quite uniform.

"The cane at Poona (*Pundia*) was grown with a series of different manures, varying very much in amount, the nitrogen from 130 to 1,000 lbs. per acre, and the phosphoric acid from 140 to 2,700 lbs. per acre; in all cases the amount of manure was large. The percentage of both cane sugar and glucose was found to be very constant in each year, namely, from 15 to 17 per cent. of cane-sugar and 1.0 to 1.8 per cent. of glucose.

"At Cawnpore a small cane, the *Matna*, was grown in 1894-95 and 1895-96, with different descriptions of manure, in varying amount (the nitrogen varied from *nothing* on the unmanured plot to nearly 200 lbs. on the most heavily manured plot); the weight of manure being in all cases very much smaller than was the case at Poona. Again, the analyses of the juice of this cane showed no relation between the amount of manure applied and the quality of the juice: the cane-sugar varied from 14 to 17 per cent. the first year and from 15 to 17 per cent. the second year, and the glucose from .3 to .5 per cent. Thirdly, at

* This is confirmed by the remarkable manner in which the Southern Marátha varieties recovered to their normal standard in the second year of cultivation at the Poona Farm, although they had deteriorated considerably in the first year's cultivation. See description of Bombay varieties pages 45 to 57.—J. M.

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Cawnpore in 1894-97 another variety was grown, a thick *Pundia* called *Madras*, and this was manured with different materials containing from 250 to 500 lbs. nitrogen per acre, the amounts being in every case *large*. The percentage of cane-sugar varied from 14 to 15·5 per cent. and the glucose from 0·5 to 0·9 per cent.

Thus the evidence adduced from three somewhat extensive series of tests pointed uniformly to the conclusion that neither the kind of manure, nor its amount, exercised any influence on the quality of the juice of sugarcane.

It so happened, however, that conflicting evidence was met with during the cold weather of 1896-97 at Cawnpore. Six varieties, three thin ones and three thick ones, have been grown at this farm for three years. One of these was the *Matna* variety already alluded to. In 1896, it was decided to grow this variety (along with the others) with large amounts of manure. It now grew much taller than usual, and the weight of crop was much increased. When, however, the juice came to be analysed, it was found that, instead of containing the 15 to 17 per cent. of cane-sugar which had been maintained for two years, the proportion had fallen to 11 per cent.; on the other hand, the proportion of juice expressible by the mill, which had previously been 45 to 50 per cent., was now found to be 60 per cent.

Another piece of similar evidence was obtained in connection with the Dumraon experiments, where it is probable that high manuring had, in the case of certain canes, reduced the proportion of sugar. But a consideration of the evidence on this subject clearly offers an explanation of the effects noticed.

It is certain that under the conditions of growth of the Poona *Pundia*, the *Matna*, in 1894-95 and 1895-96, and the *Madras* in 1896-97, manuring had no material effect; and those conditions are readily set out. The Poona cane is commonly grown with large amounts of manure, and it was similarly supplied in the experiments. The *Matna* is commonly grown with only small amounts of manure, and only small amounts were supplied to it at Cawnpore in the first two years. Thirdly, the *Madras* variety is commonly heavily manured, and the treatment for it was similar in this respect at Cawnpore in 1896-97. Thus, while the conditions of manuring assimilated to those to which the several varieties are accustomed, the proportion of sugar remained normal, whereas, if the one or two cases of sudden change in the composition of the juice due to heavy manuring are to be relied on, it would appear that a variety may produce a poor juice, if it be suddenly grown with much larger amounts of manure than those to which it has been accustomed for long periods.

It must not be supposed, however, that a less outturn of sugar was realised in the case of *Matna*. Although the percentage of sugar in the juice was less, much more juice was obtained, and the crop was about twice as heavy. So that from the economic point of view there was a considerable gain. Moreover, the evidence, such as it is, of the varieties at Dumraon, point to the fact that under the new conditions the varieties will regain their normal growth in the course of a few years. The case is indeed very similar to that referred to in paragraph 115, where the effect of change of climate is discussed, and it seems likely that a cane may suffer from either cause; the effects are however probably only temporary.

117. (1-c).—*The composition of the juice of cane which had become lodged.*—The crop of cane at Cawnpore was much lodged in 1894 by rain, and it was decided to crush the fallen cane separately from that which remained erect. It was then found that the juice of the lodged cane contained much less sugar than that in the standing cane, and the *gur* prepared from it was so full of molasses that it would not solidify. In the other two years the weather was not abnormally wet, and no further evidence of the effects of heavy rain has been obtained; but the crops at Cawnpore and Dumraon were so heavy in 1896 that some parts fell down. The juice of the fallen cane was again separately examined, with the result that it was found to contain generally a less proportion of cane-sugar, and a larger one of glucose, than was found in the standing cane. The differences were on the whole not great, and nothing like so serious as was the case with the crop which had been lodged by rain in 1894.

118. (1-d).—*The composition of the juice of the top ends of the cane*—My attention was directed to the quality of the juice in the top ends of the cane, because in the Burdwan District of Bengal it is customary to propagate the crop from the top ends only, whilst in most parts of India the usual practice consists in cutting up whole cane into pieces and propagating from them.

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"Moreover, it so happens that in no part of India is the cultivation of cane, in most respects, more perfectly carried out than at Burdwan, and one at least of the varieties there grown, is an exceptionally good one containing from 16 to 18 per cent. of sugar. In no respect, therefore, could it be said that the quality of the cane or the cultivation was inferior. Now the weight of cane which is used for sowing is very considerable, amounting to several thousand pounds per acre, and the question naturally presented itself, what sort of juice is contained in the top end of the cane, and is it an economy in the matter of sugar to propagate from the top ends only? Accordingly, several sample bundles of cane were taken at Burdwan this year, the top ends cut off, and the juice expressed and analysed from the top ends and the remaining cane, respectively. The experiment showed quite conclusively that there was much less juice in the top ends than in the main part of the stem, and much less sugar in that juice. Consequently it is apparent that, if an acre be sown with the top ends of the cane, and the main part of the cane be reserved for sugar-making, an economy in sugar will result. Taking the figures which were obtained in the experiment as a basis of calculation, this economy amounted to about 320 lbs. of raw sugar in the case of one variety, and to about half that amount in the case of another; or we may say that by propagating from the tops only, a saving of several hundred pounds of raw sugar per acre will be realised.

"It appeared desirable that other varieties should be propagated from the top ends only, in order to determine whether any deterioration of quality resulted, and this is being done at Cawnpore with cane which has always been grown from the cut-up whole cane; but unless such deterioration should manifest itself, it must mean a great saving to cultivators to plant from the top ends only.

"119. (1-e).—*The composition of the juice of different varieties of cane.*—The amount of juice expressible by the mill, and the proportion of the cane sugar and glucose in the juice, has been determined for a number of varieties, some of which have been grown at the farms, some in villages at a distance from them. The amount and quality of the juice has varied a good deal between the worst and the best.

"The proportion of juice expressible will be dealt with under (7).

"The juice of the better varieties such as the *Poona Pundia*, the *Samsdra* of Bengal, and the *Madras Ponda*, all contain high proportions of sugar varying from 14 to 18 per cent. of total sugar, and I am certain that no better cane can be obtained anywhere than these. Some of the thin varieties, too, such as the *Matna* of the North-Western Provinces, *Mungo* of Behar and *Khari* of Bengal, give a juice containing similarly high proportions of sugar. On the other hand, some such as the *Dikchan* and *Dhaul* of the North-Western Provinces have much less sugar in their juice. Of the total sugar, the greater part is of course cane-sugar.

"The glucose has in most cases been determined in the juice also, and its proportion varies from a half up to two per cent.

"The acidity in the juice was determined in a number of samples in 1896, but the results obtained I consider uncertain. The colour of the juice is so dark that a difficulty was experienced in using 'indicators.' The question of the amount and the kind of acidity is nevertheless an important one, for, as will become evident when explaining the experiments which I made to prevent inversion when boiling the juice, this constituent causes a serious loss of crystallisable sugar. What is required is a method, both simple and rapid, for determining the amount of organic acids, other than carbonic acid, which may be used in the field, and I had not time to work one out.

"120. (2).—*The relation between the amount of sugar in sugarcane juice, and its specific gravity.*—Owing to the increasingly large number of analyses of juice which it was desirable to make in connection with these sugarcane experiments, and also to the fact that a chemist is only occasionally at the farms at the time of harvest, the need became apparent of some simple method of determining approximately the amount of sugar in juice.

"In the case of sugar being dissolved in pure water, its amount may be determined with very fair accuracy by observing the specific gravity of the solution, there being a very simple relation between the two.

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"Sugarcane juice is not, however, a solution of only sugar in water; other substances are present besides, which affect the density. It occurred to me, however, that the amount of these other substances might be fairly constant, and if so, the insertion of a uniform correction would enable one to calculate the percentage of total sugar from the specific gravity.

"Accordingly I compared the specific gravity of a large number of samples of juice with the amount of sugar actually found by analyses. The result of this was, that the difference between the percentage of sugar as shown by the hydrometer, and that actually present, proved to be fairly constant as I had expected. This difference amounted to about 2 per cent. in the majority of cases, and I calculated out a set of tables by means of which any one can find out the per cent. of total sugar with the aid of a hydrometer. Of course such a method is only approximate, but the result will not be more than half a per cent. from the truth. Also it is to be observed, one only learns the amount of *total* sugar by this means, but since the amount of glucose is only small, the method will be found very useful for field work, when the more exact methods of the chemist are not available.

"121. (3) *The amount of inversion which takes place when boiling down the juice.*—All cane juice contains organic acids, and these at a boiling heat possess the unfortunate property of converting a part of the crystallisable cane-sugar into uncrystallisable glucose. So far as the *food value* of the resulting sugar is concerned, the change is probably of no great consequence.

"But in other respects the change is very serious. Not only are molasses useless and inconvenient to the refiner, to the small native refiner, just as much as to the large operator with European appliances, but to the *Bunyz* who has to store the *gur* or *gul* through the rains, the matter is of equal importance, because the larger the proportion of molasses, the more liable is the *gur* to liquefy in his *godown*. I found that, whereas in the *juice* each 100 parts of total sugar includes usually from 2 to 10 parts of glucose, in the *gur*, as ordinarily made, the proportion of glucose ranged from 10 to 20 parts. In addition, it is to be borne in mind that each part of glucose will prevent an equal weight of cane-sugar from crystallising, so that these figures have to be doubled in order to express the true effect of this glucose formation. In endeavouring to find a means of preventing the change, it was necessary to employ only such a method as the ordinary cultivator could use, and I believe I have more or less succeeded. The addition of a small quantity of quicklime in water will neutralise the acidity of the juice, and thus prevent in a great measure the process of inversion. Too much lime must not, however, be employed, otherwise the resulting sugar becomes black, and its market value decreased. Litmus paper was at first employed to detect when sufficient lime had been added; later I found that there is a natural colouring matter in the juice which could be equally well employed.

"The result of the careful addition of lime is to prevent very materially the formation of molasses, and the *gur* obtained has a much better crystal. That which has been made at Cawnpore has realised distinctly a higher price in the bazar than that produced by simply boiling down the juice. Likewise in some experiments which I made in villages on Messrs. Thomson and Myles' estate this year, the results were equally satisfactory.

"122. (4) *The amount of sugar which becomes lost in the scum:*—When boiling down the juice, scum rises to the surface and is skimmed off more or less perfectly with ladles. The amount of this scum is considerable, and it seemed desirable to make one or two determinations of the amount of sugar which must of course be carried along with it.

"Accordingly in the cold weather of 1895-96 I estimated very accurately the amount of sugar actually present in the juice, and later, after the *gur* had been made, the amount of sugar in it. The difference between these two amounts is due to the sugar which had been carried away in the scum. Four experiments were made at Cawnpore and four at Poona. The loss of sugar proved to be from 10 to 14 parts per hundred in the juice.

"This sugar, which is unavoidably taken in the scum is, however, not wasted. At Poona the people recover part of it by putting the scum into water, boiling the liquid and again skimming off the scum. At Cawnpore the scum is given to cattle as a food.

"123. (5).—*The Composition of the raw sugar*—By far the greater part of the cane juice produced in India is simply evaporated down (after removing the scum) to such an extent that on cooling the mass becomes solid. This description of raw sugar is called *gur* in the North-Western Provinces and Bengal; in the Deccan it is called *gul*. Whilst still

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hot, the raw sugar is usually run into moulds where it solidifies in blocks weighing from 25 to 100 lbs. Sometimes, as in parts of Oudh, the *gur* is made up whilst warm and soft into rounded pieces about a couple of inches in diameter, and again in other districts, e.g. Dehra Dun, it is run out on bamboo matting whilst hot and allowed to solidify in thin cakes. These are, however, minor practices, and are not deserving of recommendation. Some of the Oudh *gur* proved to be exceedingly dirty.

"The composition and colour of this description of raw sugar will vary very considerably, much depending on both the quality of the juice and the mode of working.

"If the cane becomes *laid* by rain, the juice will contain a high proportion of glucose (*vide* paragraph 117) and the resulting *gur* will be soft. Again, if the juice be poured through a cloth or brass wire strainer, much dirt and bits of cane are separated; it is indeed surprising how much dirt can be removed from the juice by this means. During the boiling process the more perfectly the skimming is effected, the purer will be the product and the better its colour.

"Finally, if the acidity of the juice be neutralised, the *gur* will contain a lower proportion of molasses (*vide* paragraph 121).

"Some samples of cultivators' *gur* from Oudh which I analysed, contained of cane-sugar from 63 to 72 per cent., glucose from 9 to 10 per cent., mineral matter from 3 to 4 per cent., water and other impurities from 15 to 24 per cent.

"The samples of *gur* made from *laid* cane at Cawnpore in 1895, contained from 64 to 68 per cent. cane-sugar and 13 to 14 per cent. glucose, whereas the *gur* from the erect cane of the same crop contained from 70 to 75 per cent. cane-sugar and 8 to 10 per cent. glucose. But with good cane and careful manufacture, the *gur* will contain from 70 to 78 per cent. cane-sugar and from 5 to 15 per cent. of glucose.

"124. In addition to the solid *gur* or *gul*, another description of raw sugar is prepared by removing the mass from the fire at a somewhat earlier stage, and before all the water has been boiled out. The resulting sugar never solidifies entirely, but a great deal of the cane-sugar crystallises out during the first few days, and the mass becomes semi-solid. It goes by the name of *râb* in many parts, but in parts of Bengal it is also called *gur*.

"The composition of *râb* will vary somewhat according to the amount of water which is left in it. That made at Burdwan this year contained from 65 to 73 per cent. cane-sugar and 5 to 19 per cent. glucose, but one of the samples was undoubtedly below average for some reason or other. Other samples from Behea, which were prepared in my presence, contained from 69 to 75 per cent. cane-sugar and only $2\frac{1}{4}$ to 5 per cent. glucose, and there is no doubt that, given good cane and careful manufacture, the latter standard can be maintained.

"This description of sugar is prepared specially for the purpose of refining. Frequently it is put into sacks which are then placed one on another in order to increase the pressure on the lower ones, and the molasses gradually run out more or less. Or again the refining process is effected by placing the *râb* in a vessel having a "false bottom." A wet weed (*sewar*) is then placed on the surface, and the molasses gradually leave the top layer of sugar. This purified layer is then scraped off, and the *sewar* applied to the next layer, and so on until the whole has been refined. In neither of these refining processes are the molasses obtained in a fit state for human consumption, and this means a loss of fully one-third of the sugar operated upon.

"One sample of sugar refined by this process contained 96.6 per cent. of cane-sugar and 0.89 per cent. glucose.

"125. (6) *The hand centrifugal sugar separator*.—Another much better means of separating the molasses from the sugar crystal of *râb* have been provided by Messrs. Burrows, Thomson and Mylne of Behar, who have introduced a centrifugal machine, worked by one man at a time, by means of which the molasses are separated in a few minutes. About 26 sers of *râb* are placed in a machine at once, the separation is effected in about 20 to 30 sers, and the resulting sugar removed and the machine cleaned out ready for the next charge within 5 minutes. About 50 maunds of *râb* can be readily worked off in one day by each machine. The molasses are recovered quite clean and sweet and are boiled down to form solid *gur*.

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"The proportion of clean crystallised sugar (what is called *brown sugar* in England) which is obtained, will of course vary somewhat with the nature of the *rab* operated upon. In one of Messrs. Thomson and Mylne's experiments a yield of 40 per cent. was obtained, in another 52 per cent. In two experiments which I made 48·8 and 51·9 per cent. was obtained.

"The amount of *gur* obtained after boiling down the molasses seems to vary between 25 and 40 per 100 of *rab* operated upon.

"The so-called 'turbine' or 'centrifugal' sugar is very fairly pure. I have analysed several samples, from which it appears that it contains from 90 to 95 per cent. of cane-sugar, from $\frac{3}{4}$ to 2 per cent. of glucose, from $\frac{1}{2}$ to 3 per cent. of moisture, from $\frac{3}{4}$ to $1\frac{1}{4}$ per cent. of mineral matter and from 2 to 3 per cent. of other (organic) impurities.

"The *gur* obtained by boiling down the molasses is quite as good as much of the *gur* which is made by the cultivators direct from the juice. Judging by the composition of some samples which I have examined, it appears to have about the following composition:—cane-sugar from 65 to 80 per cent., glucose from 5 to 14 per cent., mineral matters from $3\frac{1}{2}$ to 4 per cent., water and other impurities from 10 to 20 per cent.

"In addition to a regular trade which has sprung up in the Shahabad District in 'centrifugal' sugar, which is exported long distances by rail, a similar trade has arisen in the *gur* made from the molasses. I believe that a great future exists for this hand centrifugal machine, for it is clear that a very material economy in sugar must take place by its means over the native processes in which the greater part of the molasses becomes unfit for human consumption, and thus actually lost entirely so far as food-supply is concerned.

"126. (7) *The total amount of sugar in sugarcane and the amount remaining in the crushed refuse.*—Since it is obvious that by no process of simple crushing, all the juice can be expressed from cane, it becomes an interesting question, how much is left with the refuse?

"The matter is of far greater importance than might at first sight appear. It has generally been assumed in India that everything related to the crushing process depends entirely on the mill, and the question of difference in the variety of cane has rarely, if ever, been considered.

"The first year's crushing of cane at the farms brought a very important fact to light. At Poona about 70 per cent. of juice was obtained from the cane there grown; at Cawnpore only about 50 per cent. was expressed. Since the mills which were used at the two places were essentially different, one might have said that the mills at Poona were infinitely better than those at Cawnpore. I knew, however, that such was not the case, some of the mills at Cawnpore having been of the very best workmanship and pattern.

"The difference between 50 and 70 per cent. of juice is so great, that I decided to make some careful experiments in 1896 to find out what the true state of things really was. Accordingly the total amount of sugar and of juice was determined in two lots of the Poona cane at Poona, and in five different varieties grown at Cawnpore. The amount of juice expressed was also known, as well as amount of sugar in the latter, and the difference between the two gives the amount left in the crushed refuse cane.

"(It may be here mentioned that I found it impossible, for technical reasons, to determine the amount of sugar in the refuse *directly*. When working in the field out of reach of any laboratory, only certain appliances can be used, and I had therefore to be content with taking the *difference* figure above indicated, as representing the quantity of sugar in the refuse.)

"The methods employed are sufficiently clearly set forth in paragraphs 11 to 15 of *Agricultural Ledger No. 19 of 1896*.

"The result of this investigation showed quite clearly on what factor depends the amount of juice which a good mill can express from sugarcane. The total amount of juice found in the two extreme cases examined varied from 85·2 to 91·5 per cent. The amount expressed from 45·4 to 72·2 per cent. A comparison of these figures throws no light on the subject, for there is obviously no simple relation between the two cases, in one 45 out of a total of 85 and in the other 72 out of a total of 91 per cent. of juice.

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"If, however, another item in the composition of cane, namely the *fibre*, be brought into the comparison, and its effect be considered, the cause of these variations in the amount of juice expressed becomes evident.

"It will be readily understood that so soon as cane is crushed up by the mill and the cells opened, the only physical force which prevents *all* the juice from running out is that of adhesion. The fibre of the cane becomes, in fact, a spongy material, and just as it is impossible to press all the water out of a wet sponge, so likewise is it impossible to express all the juice out of cane.

"But the analyses of the several varieties showed further that *quite independently of the variety* the crushed refuse cane contained approximately always the same amount of juice. At Poona the crushed cane consisted of 70 to 71 per cent. of juice and 29 to 30 per cent. fibre; at Cawnpore with entirely different mills and other varieties of cane, the refuse consisted of 72 to 75 per cent. of juice and 25 to 28 per cent. of fibre.

"Thus the proportion of juice in the crushed cane remained approximately constant, *i.e.* the fibre of these different varieties held approximately the same amount of juice in each case. Referring again now to the instances already alluded to, in one of which a cane contained 85 per cent. of juice and yielded only 45 per cent. at the mills, and in the other, the cane contained 91.5 per cent. juice and yielded 72 per cent. at the mills, if the amounts of crude fibre present in these canes be considered, its effect becomes apparent. The former contained 15 parts of fibre per 100 of fresh cane, and this 15 of fibre held 40 parts of juice, allowing only the other 45 parts to run out when pressed. In the second case, 100 parts contained 8.5 parts of fibre and this 8.5 parts of fibre held 19.5 parts of juice, allowing the remaining 72.2 parts to run out when pressed. And, as a result of this investigation, it may be said that, even with the best of mills, each part of fibre in the fresh cane will hold twice to two and a half times its own weight of juice when pressed, and allow only the surplus to run out.

"It becomes therefore an all-important matter in the selection of varieties of cane to choose those which contain low proportions of crude fibre. Speaking generally of varieties, I have found it almost uniformly the case that the small varieties commonly grown for crushing purposes in the North-Western Provinces and Behár, contain high proportions of crude fibre, and yield only some 50 to 55 per cent. of juice at the mills. On the other hand, the thick canes, some varieties of which are grown for chewing in the North-Western Provinces, others for crushing in Bengal and the Deccan, contain uniformly low proportions of crude fibre and yield from 65 to 70 per cent. of juice at the mills.

"Thus, even assuming that the juice of the thin varieties is just as rich in sugar as that of the thick ones (and it is probable that it is not so rich), the introduction of thick varieties in place of thin ones, would mean a direct gain in sugar production of about 25 to 30 per cent. over that at present obtained, and this without any further expenditure on manure, water, &c.

"127. (8) *The amount of phosphoric acid and nitrogen in the sugarcane crop.*—At Poona the cultivators employ very large amounts of manure for this crop, and it has been further demonstrated by the field experiments that whilst it may be the case that these amounts are somewhat larger than is necessary, very heavy dressings of manure are desirable, and will readily repay the initial cost. So far as one can draw any conclusion from the three years' experiments, it would appear that 500 lbs. of nitrogen per acre should be given in order to obtain a full crop. The amount of phosphoric acid required is still quite uncertain. Since it is necessary to apply such large amounts of manure, it seemed desirable to gain a knowledge of the amount of these plant foods which are extracted from the soil by cane crops generally, and I made several determinations to this end. The cane, green tops, and dry leaves of crops at Cawnpore and Dumraon were weighed, and portions of each submitted to analyses. The results obtained showed that in crops weighing 60,000 to 70,000 lbs. there was generally contained some 50 to 60 lbs. of nitrogen and the same amount of phosphoric acid. The crops at Poona are fully twice as heavy as this, and it may therefore be said that they remove 100 lbs. or more of each of these plant foods. There is consequently a considerable balance unaccounted for. I have examined the results of the analyses of the Poona (Manjri) farm soils, and judging by these, this balance of plant food is still in the soil, and no material amount has been lost by drainage up to the present.

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"128. *Concluding remarks.*—As to the general importance of experiments on the sugarcane crop, it is almost unnecessary for me to say anything. It is clear in the first place that so long as India has to import sugar (the net amount is about 75,000 tons annually), there is room for an increased production. It is also clear that, whilst an article of diet, which is common to the people generally, is imported, the cost of production is higher than it should be. But this is not all, for the greater part of the sugar produced goes to the cities, and it thus becomes in a measure a luxury. Then, too, there is the difference between the outturn per acre as realised in the Deccan and Bengal on the one hand, where, with good varieties and good methods of cultivation, some $2\frac{1}{2}$ to 4 tons of raw sugar is obtained, and in Behar and the North-Western Provinces on the other, where the outturn is certainly not more than 1 to $1\frac{1}{2}$ tons per acre, and is often much less.

"As has been shown in the course of this section of my report, there is no need to go outside of India for good varieties, nor to other countries for good methods of cultivation. The best of varieties are met with; and the methods of cultivation in some parts are very perfect. What is wanted is the introduction of these good varieties and good methods into those parts, particularly the North-Western Provinces and Behar, which Provinces, it must be recollected, include much the largest area under cane of any Provinces of India."

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DESCRIPTION OF VARIETIES OF SUGARCANE.

BY DR. LEATHER AND MR. MOLLISON.

The following notes contain a description of a number of varieties of sugarcane which have been examined. It is possible that some of these are cultivated in other parts of India; doubtless also there are many other varieties which still remain to be described, and the writers think that the following introductory remarks will be of assistance to other agriculturists not only in the recognition of varieties included in these notes and growing elsewhere, but that they will admit of descriptions of other varieties being reduced to a common standard. It must be stated, however, at the outset, that, although among varieties of sugarcane each possesses particular markings or colours (to be presently dealt with in detail), there is usually in the case of any one particular variety considerable latitude within which appearances vary. For example, if a number of canes of the *Madrâsi Pounda* of the North-Western Provinces or the *Pundia* of Poona or the *Samsâra* of Burdwan be examined, it can be at once seen that the colour varies in any of these varieties from green to straw yellow, but the colour may be modified so that some canes may be almost entirely green whilst in others some portions may be entirely yellow or the yellow may have an orange tinge. The latter tinge is particularly noticeable on canes growing on the headlands and therefore rather fully exposed to the sun. In the *Madrâsi Pounda* this orange yellow colour is sometimes the general colour of the whole cane. The same variety may vary in shape between the nodes; a cane may be generally of, say type A (*vide* diagram at page 41), but some of the canes in the bundle may possess shape of type C, more especially at the lower end; or again a cane may have grown in type E at one part (frequently the upper end), the remainder being straight.

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2. Correspondingly great variations will be found among varieties in respect of other particulars, such as the extent to which aerial roots develop, the colour and shape of the rings at the nodes &c.

At the same time each variety is distinct, and when canes of two varieties are placed together, the differences become much more apparent than if they are separately examined.

Occasionally no differences can be detected between the striped canes of two varieties. For example, the *Mungo* and *Bhurli* canes of Behar are so much alike that they are indistinguishable when stripped of the leaves; the leaves of the two are, however, quite distinct, those of the *Mungo* being of a paler green and inclined to crumple up, whilst those of the *Bhurli* variety are darker in colour and remain flatter. Such a case is, however, in the experience of the writers, exceptional, and varieties as a rule are sufficiently distinct to enable one to recognize them without the leaves. In fact the leaves are commonly of but little assistance in determining the variety.

3. In the following paragraphs the points which have been more particularly examined are dealt with in detail.

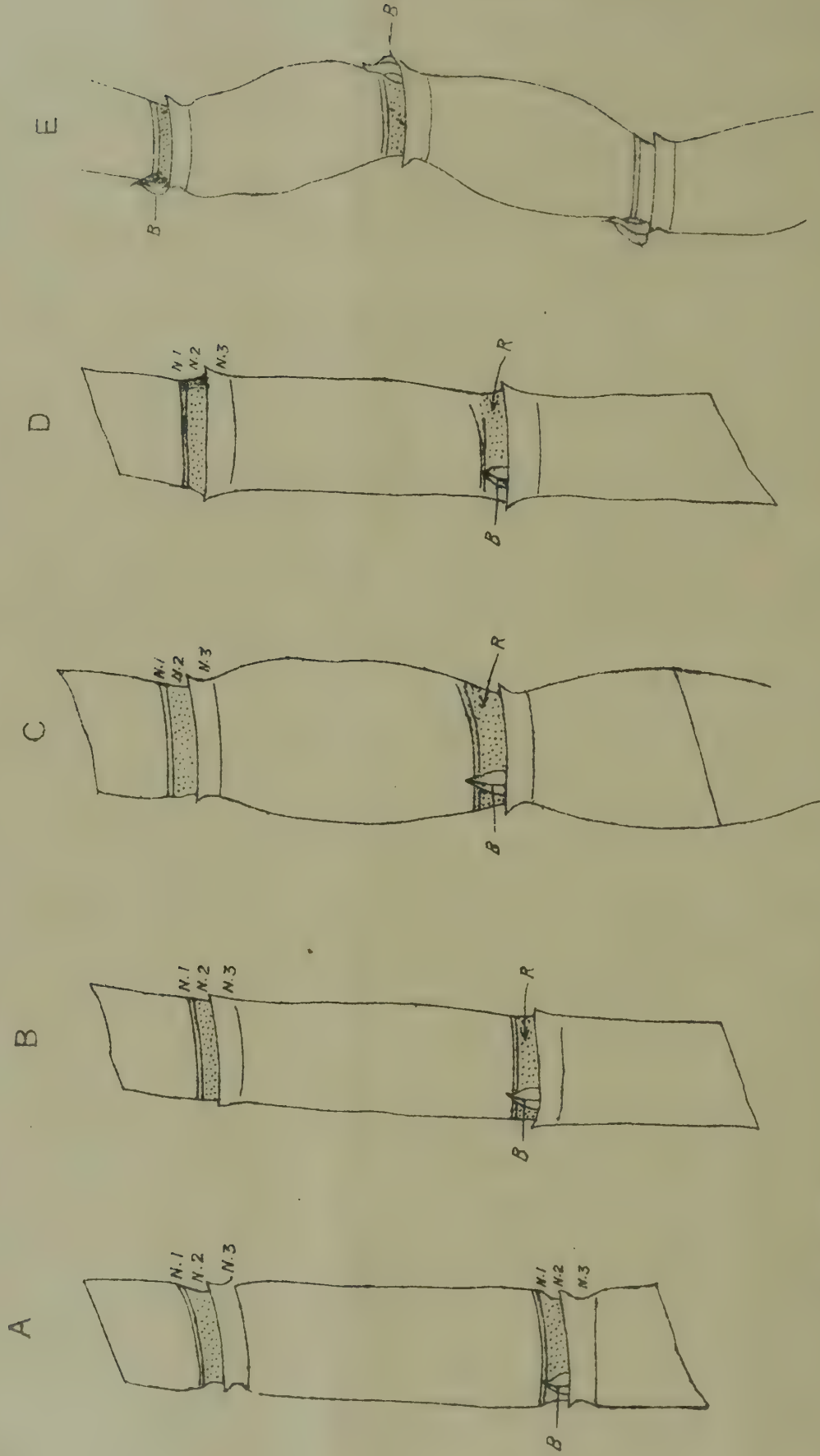
Colour.

4. *Colour*—Sugarcane may be of the following colours:—

- (1) Pale yellow or drab.
- (2) Pale yellow and green.
- (3) Nearly entirely green.
- (4) Purple or purple red.
- (5) Purple and yellowish green in stripes.
- (6) A more or less intimate mixture of dull purple and dull green best described as a dirty colour.

Of these, however, only (4), (5) and (6) are really so distinct that the cane can be definitely said to belong to the one or the other. A striped cane for instance is always striped purple with yellow or yellow-green. A cane that might be classed as wholly purple, when minutely examined, may or may not have longitudinal stripes of a darker or lighter colour, these being most distinctly marked on the upper internodes and only faintly marked on the lower. In purple canes the depth of colour may vary from very dark purple to a light reddish purple. It is at times practically impossible to decide whether a particular cane should be classed as pale yellow or drab, or pale yellow and green, and again it is hard to differentiate between pale yellow and green and nearly entirely green. It has been found that some varieties are almost or quite destitute of green in a certain field, e.g., *Betta Kabbu* at Belgaum and *Dhaur* and *Rakra* in the North-Western Provinces; but tinges of green are frequently found on the same variety when cultivated under other conditions, e.g., *Betta Kabbu*, which at Poona had tinges of green on it. The same may be said of canes being

DIAGRAM SHOWING DIFFERENT TYPES OF CANE



B- Buds
R- Root dots
N.1, N.2, N.3- Nodes.

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all green. Sometimes a variety will be quite destitute of yellow in a certain field, but the same variety will be found in another field or locality to be quite yellow in places. For example the *Mungo* at Rosa was entirely green, whilst at Bára Banki it was partly yellow. The simplest plan is therefore to class all canes of a yellow or yellowish-green or green colour together and state the colour as found in a particular variety when examined.

Canes might then be divided into four classes as regards colour; namely—

- (1) Yellow or green or both.
- (2) Purple.
- (3) Purple and yellowish green in stripes.
- (4) Purple and green mixed to form a dirty colour.

It not infrequently happens that a yellow green cane will have very distinct patches of red or pink upon it. Such for example is the *Ramwie* of Sitápur District, North-Western Provinces. But this is quite distinct from the purple colour of canes belonging to classes 2 and 3.

5. *Other points of colour.*—In reference to the colour of canes several other points are deserving of notice.

Very frequently patches or smudges of dirty black are found adhering to a cane. This is quite external and may readily be rubbed off. It cannot be said that these smudges are characteristic; they are found on some varieties, not on others growing in the same field and the origin of the smudges has not been determined. Then tinges of pink or red appear on some canes, especially just above the nodes where the leaf still adheres. This colour is not always on every cane of one variety in the same field but is apparently a *common* characteristic on some varieties. For instance the *Ramwie* cane of the North-Western Provinces was tinged with pink at Sitápur (Oudh) and in one of the fields examined at Bára Banki (Oudh), but in another field of this variety at Bára Banki this colour was almost entirely absent.

6. *Bloom.*—There is on some varieties a mass of waxy bloom which covers the cane more or less, and the presence or absence of this bloom, as also the degree to which it covers a cane seems to be quite characteristic of varieties.

7. *General shape of Cane.*—Sugarcanes have very characteristic shapes, some of the principal ones being depicted in the accompanying diagram and shown as A, B, C, D, and E. Of these the first three are perhaps the most common.

A—represents one which has distinct contraction at the nodes, but is otherwise a cane of practically uniform thickness.

Bloom.

General
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B—represents a cane which is practically of uniform thickness throughout its length there being no perceptible contraction or expansion at the nodes.

C—represents a cane which is contracted at the nodes and becomes distinctly enlarged between the nodes.

D—represents one in which the nodes are distinctly larger than the cane and it then becomes narrower between the nodes. This apparently is not a common shape.

Finally, E—represents a cane which has a zigzag form from joint to joint.

**Colour of
nodes.**

8. *Colour of Nodes.*—The nodes of canes are very characteristically coloured or marked. There are always two bands, one immediately above the node marked N_2 in the diagram. This is about as broad as the buds are long *before they commence to grow*; also it is from this band that the roots develop either as aerial roots or when cane sets are planted. The little dots or growing points of the future roots are always perceptible. In some varieties they are much more distinct than in others. In fully mature canes the root dots of the lower nodes present a roughened appearance as if the roots had started to grow. At the upper nodes they present a smooth surface. The colour of the root dot band varies but is generally lighter coloured than the main part of the cane. Immediately *below* the node is another band, marked N_3 in the diagram, of about the same breadth as the upper one. This band is generally of a grayish or bluish gray colour occasioned partly by the coating of wax which is invariably present on this part of a cane, however little wax may be attached to other parts; the gray colour commonly terminates suddenly, thus making a very distinct band; it sometimes however extends downwards on the main part of the cane and only gradually changes to the general colour of the cane. Such is the case for example on some canes of *Hullu Kabbu* of Belgaum.

**Shape of
band.**

9. *Shape of Band.*—The shapes of these two bands also vary. Sometimes the cane is contracted at both bands, but more commonly the contraction is only slight at the upper one but considerable at the lower one. The different types of nodes are graphically represented in the diagram, of which A, B, and C are very common. In addition to these, there is a ring marked N_1 in the diagram, which is common to many varieties, but almost, if not quite, absent in the case of others. The ring, if distinct, is about $\frac{1}{16}$ " wide, and is commonly of a decided orange colour. Very frequently, however, it is not uniformly distinct in any one variety, and not of uniform width or prominence on all the nodes of the same variety.

Buds.

10. *Buds.*—The buds vary in shape, size and colour among varieties, but since their shape and colour vary according to whether they have commenced to grow or not, care must be taken to notice this point in examining them. At the same time on some varieties

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(if not over-ripe) they are uniformly rounded or oval, whilst in the case of others they are more pointed. In some varieties the scale-like covering which protects the buds is coarse and fibrous in texture, in others it is smooth, thin and shining

11. *Root Dots*.—Regarding the little dots, indicating the seat of the growing point of the future root, not much need be said. They are distinct on some varieties but only just perceptible on others.

Root dots.

12. *Aerial Roots*.—Sugarcanes have a general tendency to throw out aerial roots from the nodes which are near the ground, but some varieties produce them not only close to the ground, but for some distance up the cane. Occasionally this is a very pronounced characteristic. For example the *Sháháranpuri* and the *Madrási* or *Madrási Ponda* of the North-Western Provinces and the *Samsára* of Bengal frequently produces them over its entire length and moreover the aerial roots of one node grow towards and join those of the next node.

Aerial roots.

13. *Girth*.—The girth of canes varies apparently not only between varieties, but also according to the perfection of growth of the variety. Generally, however, it may be said that the girth of a thin specimen of any one variety will not be less than $\frac{3}{4}$ th of that of a really good specimen of that variety. For this reason the girth of a cane is a most important consideration. If an unknown variety has a general thickness of 2" but is similar in other points to one having a general girth of 4", it may be said with certainty that they are different varieties. The girth of some varieties is almost uniform throughout the entire length. On the other hand sometimes canes are thinner at the top end than the bottom and less frequently they are thinner at both ends than at the middle.

Girth.

14. *Length between Nodes*.—The length between the nodes of a cane varies very considerably, but nevertheless well grown canes of all varieties appear to be characterised more or less in this particular.

Length
between
nodes.

The *Hullu Kabbu* of Belgaum, for example, has generally long inter-nodes, whilst the *Betta Kabbu* of Belgaum has frequently short ones. The *Malabári* cane of Surat has generally long inter-nodes. The *Meva* cane of the same district has invariably short inter-nodes. If a crop of cane of any variety is stunted in growth for want of manure or any other cause the inter-nodes are invariably short.

15. But although such broad distinctions as the above may be made between canes generally, it is not always easy to decide to which variety a cane belongs. The shape of canes and their colours merge in a measure the one into the other.

General
remarks.

In the case of colour, any cane may be easily placed under one of the four groups which have been suggested, but in the case of the colour and distinctness of the bands at the nodes, whether the ring (marked N₁ in the diagram) is distinct or not, whether a cane is enlarged or

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**DESCRIPTION
OF
SUGARCANE.**

**Vernacular
Names.**

contracted between the nodes &c., whether aerial roots are common to a variety, what the shape of the buds is &c. &c., it is frequently difficult to say positively what would be an accurate description for any one variety. Nevertheless if, in describing canes the various points be noted on the above indicated lines, descriptions given by different persons of the same variety would probably agree more completely, than if such descriptions were referred to no general standard.

16. *Vernacular Names.*—That the cultivators can recognise the varieties of their particular district there is not the least doubt, and if they all spoke the same tongue the recognition of the many varieties grown in India would be a very simple matter. Unfortunately the names given by the people are not always of much value.

In the North-Western Provinces and Oudh not much difficulty has been experienced in this respect.

In the Southern Marátha Country, however, much confusion exists among the names as the following instances will show. There are three thick canes grown, one being a green-yellow cane (the *Pundia* of Poona), a second is entirely purple and the third is striped purple and yellow-green.

The *Pundia* is called *Pundia* throughout the Southern Marátha Country, but it is also called *Bile Kabbu* (i. e. white cane) and *Rasdáli Kabbu* at Dhárwár. The purple cane is generally called *Káre Kabbu*, but is also called *Rasála Kabbu* in some villages. The striped cane is called *Rasála*, *Rasáli*, *Rasváli* or *Rámrasdáli*.

When one enquires into the meaning of these words the cause of the confusion becomes apparent. *Bile* means “white,” and is doubtless applied by the people to that variety of the three which is yellowish green in colour (that is lightest in colour) to distinguish it from the purple ones.

Rasála or *Rasváli* or *Rasdáli*, all of which are probably the same word differently pronounced, means juicy, and the term is applied to all the three varieties because they are more juicy than the thin varieties also grown in the Southern Marátha Country.

In the name *Rámrasdáli*, the prefix *Rám* is derived from *Rama* = God, and is probably applied to the striped cane because it is the prettiest of the three.

17. In finding the different varieties of cane in a district the cultivators have been found of the greatest assistance to the writers; they will readily indicate the fields in which the different varieties are grown and the measurements and other descriptive remarks may then be made without any trouble.

18. *The juice of canes.*—The foregoing has only reference to the appearance and size of canes. It remains to say a word with regard to the juice.

The percentage of juice obtainable in the iron mill from any variety
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**Juice of
cane.**

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Sugar.VARIETIES
OF CANE
EXAMINED.

is apparently fairly constant. (*Vide* for example the varieties grown at Belgaum and Dhârwâr described further on.)

So far as the experience of the writers goes, thick canes will give from 68 to 72 per cent., while from thin ones only 50 to 60 per cent. will be obtained. Consequently it is most important to find out if this rule may be relied upon. The subject is dealt with more fully in *Agricultural Ledger No. 19 of 1896*, at pages 18-20. The proportion of juice extractable may be readily determined by passing about 100 lbs. of cleaned cane of any one variety through an iron mill and weighing the juice obtained. The percentage of sugar in the juice can be approximately determined from the specific gravity, and this subject has been dealt with in a special paper on the chemical composition of sugarcane. (*Agricultural Ledger Series No. 3 of 1897.*)

DETAILED DESCRIPTION OF DIFFERENT VARIETIES OF SUGARCANE.

(A).—BOMBAY PRESIDENCY VARIETIES.

(Examined by MR. MOLLISON.)

Variety—**Khajuria** or **Meva**.

Where grown—Surat District.

General Appearance—A yellow green cane of medium thickness; tall and fairly soft; used only for raw eating; tillers freely; ratoons well; grows in clumps.

Type—C; internodes only slightly bulged.

Bloom—A little.

Nodes—Ring N₁—Not distinct.

Band N₂—Irregular in shape; yellow or cream colour; root dots well marked.

Band N₃—Well defined; blue-grey colour.

Height—About six feet without tops when well grown.

Girth—3¼" to 3¾"; almost uniform from root to top.

Internodes—2½ to 3 inches; characteristically short.

Aerial Roots—On 3 or 4 nodes near root only.

Buds—Very prominent; rounded; sharp point; covered with shining scale-like covering, except on lower nodes, where the covering is brown and fibrous.

KHAJURIA
OR MEVA.

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Cultivation of Sugarcane in the

VARIETIES
OF CANE
EXAMINED.

Poona Farm Crop.

DR. LEATHER'S *Analysis*—

1896.

1897.

(Fresh imports.)

(Acclimatized 1 year.)

Percentage of juice to cane	...	59.15	67.25
Do. of sugar to juice	...	10.98	14.80
Do. of glucose in juice	...	1.40	1.00

MALABARI.

Variety—**Malaba'ri.***Where grown*—Surat District.*General Appearance*—A fairly thick, tall, soft cane; yellow-green colour; cane generally somewhat bent at top end; does not ratoon well.*Type*—C; internodes fairly bulged.*Bloom*—Very little.*Nodes*—Ring N₁—Indistinct on lower nodes; fairly well marked on upper nodes; pale yellow and green.Band N₂—Yellow and green; root dots well marked.Band N₃—Light blue-gray colour.*Height*—7½ to 9 feet, without tops, when well grown.*Girth*—4" to 4¾".*Internodes*—3½" to 5½".*Aerial Roots*—On 3 or 4 lower nodes only.*Buds*—Very small; covered with fibrous dull-brown covering.VANSI OR
BAMBOO;
BETTA
KABBU.*Variety*—**Va'nsi** or **Bamboo**, same as **Betta Kabbu** of Southern Marátha Country.*Where grown*—Surat District; Belgaum.*General Appearance*—A cream coloured or light yellow cane; vertically scored with black or brown lines; very tall; thin and hard; of uniform thickness throughout; the leaves are narrow and long and the dried dead leaves enclose the cane, and thus protect it from damage by jackals and pigs.*Type*—B.*Bloom*—Good deal; black patches numerous.*Nodes*—Ring N₁—Distinct dull yellow colour.Band N₂—Regular in width; cream colour; root dots not numerous, and not distinctly marked.Band N₃—Not well marked; light-grey colour; sometimes nearly white.

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VARIETIES
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EXAMINED.

Height—Without tops 8 feet; some canes 10 feet long, when well grown.

Girth— $2\frac{1}{2}$ " to $2\frac{3}{4}$ ".

Internodes— $3\frac{1}{2}$ " to 5".

Aerial Roots—On 4 to 6 lower nodes.

Buds—Rounded small; not prominent; shining light green scale covering on upper, and brown or *kháki* scales on lower buds.

DR. LEATHER'S <i>Analysis</i> —	Belgaum Crop, (Betta Kabbu) 1896. (Local.)	Poona Farm Crop, (Bamboo or Vánsi) 1896. (Fresh imports.)	1897. (Acclimatized 1 year.)
	(Local.)	(Fresh imports.)	(Acclimatized 1 year.)
Percentage of juice to cane ...	60.00	57.70	59.00
Do. of sugar to juice .	12.64	9.53	14.50
Do. of glucose in juice. 0.95		1.54	1.00

Variety—**Bhuri.**

BHURI.

Where grown—Surat District.

General Appearance—A fairly tall, moderately thick, hard cane; the colour varies between the lower and upper internodes considerably; the lower ones are a dirty-looking admixture of brown, dull purple, and dull green; the upper nodes are dull purple mixed with a good deal of dull green; the canes are mostly scored or blotched with gray.

Type—E; only slightly zig-zag in shape.

Nodes—Ring N₁—Not very distinctly marked.

Band N₂—Distinctly marked but varies with the cane in colour between upper and lower nodes; root dots very prominent.

Band N₃—Hardly observable in lower nodes; a ring of grey bloom on upper nodes.

Height—Without tops 6 to 7 feet when well grown.

Girth— $3\frac{1}{2}$ " to $3\frac{3}{4}$ ".

Internodes— $3\frac{1}{2}$ " to $4\frac{1}{2}$ ".

Buds—Fairly large; flattened; pointed; covered with fibrous *kháki* coloured scales.

Aerial Roots—On lower nodes.

Variety—**Phojbhuri.**

PHOJBHURI.

Where grown—Surat District.

General Appearance—Very like *Bhuri* in appearance, excepting that the colour is yellow green on upper internodes, but irregularly tinged here and there, with brown and purple on lower internodes.

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Type—E ; only slightly zig-zag in shape.

Bloom—A little.

Nodes—Ring N₁--Faintly marked.

Band N₂--Irregular in width ; yellow or green in colour ; root dots fairly distinctly marked.

Band N₃—Faintly marked on lower nodes, but more distinctly on upper ; blue-gray colour.

Height—6 to 7 feet when well grown.

Girth—3½" to 4".

Internodes—3½" to 4½".

Buds—Medium size ; flat ; pointed ; covered with *kháki* coloured scales.

Aerial Roots—On lower nodes.

SONGADI.

Variety—**Songađi.**

Where grown—Surat District.

General Appearance—A dull purple mixed with dull green ; scored irregularly with *kháki* coloured marks ; this cane is tall, hard, and nearly of uniform thickness throughout the whole length

Type—E.

Bloom—None.

Nodes—Ring N₁—Very wide and irregular in shape ; varies in colour, generally purple.

Band N₂—Irregular in shape, and colour ; root dots distinct, and lighter in colour ; thin band.

Band N₃—Regular in shape, but varies in colour throughout the length of the cane in a very erratic manner.

Height—8 to 10 feet without tops, when well grown.

Girth—3½" to 4".

Internodes—5" to 6".

Aerial Roots—On lower nodes only.

Buds—Fairly large, flat, pointed, and *kháki* coloured.

KÁLI JÁDI.

Variety—**Ka'li Ja'đi.**

Where grown—Surat District.

General Appearance—A tall, hard cane of almost uniform thickness from root to top ; dull purple in colour ; scored and blotched with *kháki* colour.

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(James Mollison.)

SACCHARUM:
Sugar.VARIETIES
OF CANE
EXAMINED.*Type*—E ; but internodes only slightly zig-zag.*Bloom*—A little.*Nodes*—Ring N_1 —Indistinct on lower nodes ; distinct and yellow-green colour on upper nodes.Band N_2 —Purple with faintly marked root dots on lower nodes ; pale green on upper nodes.Band N_3 —Distinct band of blue-grey bloom.*Height*—6 to 7 feet, when well grown.*Girth*— $3\frac{1}{2}$ " to 4".*Internodes*—4" to $4\frac{1}{2}$ ".*Aerial Roots*—Very few.*Buds*—Small, flat, blunt, and *kháki* coloured.*Variety*—**Deogadi.***Where grown*—Ratnágiri District.*General Appearance*—A very tall, straight, fairly thick cane ; moderately hard ; smooth ; yellow and pale green in colour.*Type*—A ; internodes very slightly bulged.*Bloom*—Very slight.*Nodes*—Ring N_1 —Distinctly marked ; very regular in width ; narrow ; varies in colour, mostly deep yellow.Band N_2 —Very regular ; distinctly marked ; green-yellow in colour ; root dots numerous and very distinct.Band N_3 —Grey-blue in colour and very distinct.*Height*—7 to 8 feet without tops ; very well grown canes over 10 feet without tops.*Girth*— $3\frac{1}{2}$ " to $4\frac{1}{4}$ " ; middle internodes slightly thicker than lower and upper ones.*Internodes*— $3\frac{1}{2}$ " to $5\frac{1}{2}$ ".*Aerial Roots*—None.*Buds*—Small, rounded, fairly sharp points ; covered with a shining scale covering ; varies in colour.DR. LEATHER'S *Analysis*—

	Poona Farm Crop.
	1896. 1897.
	(Fresh (Acclimatized
	imports.) 1 year.)

Percentage of juice to cane	...	70.50	68.0
Do. of sugar to juice	...	11.46	14.9
Do. of glucose in juice	...	1.87	0.9

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Sugar.

VARIETIES
OF CANE
EXAMINED.
MÁHIM YEL-
LOW GREEN;
PUNDIA.

Cultivation of Sugarcane in the

Variety—**Máhim Yellow Green**; same as Poona **Pundia** and **Pundia** of Belgaum, &c.

Where grown—Máhim, Thána District.

General Appearance—A thick, soft, tall cane tapering to small internodes at the top; yellow green in colour; cane generally bent, or crooked.

Type—C; internodes bulged considerably, especially at the top end; cane much inclined to crack vertically before ripening like all soft thick varieties; ratoons well.

Bloom—Good deal.

Nodes—Ring N₁—Irregular; not particularly noticeable; orange.

Band N₂—Wide and irregular in shape; yellow or yellowish green; root dots numerous and easily seen.

Band N₃—Wide; distinct; blue grey in colour.

Height—7½ to 9 feet without tops; some canes 10 feet long.

Girth—4½" to 5".

Internodes—3½" to 5".

Aerial Roots—Few or none.

Buds—Rounded, prominent, moderate in size; covered with dull brown or *kháki* fibrous covering.

DR. LEATHER'S *Analysis*—

	Poona Farm Crop.			Belgaum Crop. (Pundia.) 1896. (Local.)
	(Máhim Yellow Green.) 1896. (Fresh im- ports.)	1897. (Acclima- tized 1 year.)	(Pundia.) 1896. (Local.)	
Percentage of juice to cane ...	71·00	70·58	68 to 73	68 to 73
Do. of sugar to juice ...	12·39	14·80	16 to 17·4	13·71 to 17·49
Do. of glucose in juice ...	1·87	0·80	1·2 to 1·6	0·83 to 1·57

GREEN
MAURITIUS.

Variety—**Green Mauritius**.

Where grown—Imported in 1893 by the Bombay Agricultural Department.

General Appearance—A tall, moderately thick, fairly hard cane, lower internodes green; colour changes gradually towards the top to a pale yellow tinged with green; cane flowers freely, and inclined to produce side shoots prematurely; it tillers well, and ratoons well.

Type—A.

Bloom—None.

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Sugar.VARIETIES
OF CANE
EXAMINED.

Nodes—Ring N_1 —Well marked; rather wide; much the same colour as the cane.

Band N_2 —Mostly pale yellow tinged with green; regular in width; root dots fairly well marked.

Band N_3 —Distinct; light blue grey in colour.

Height—7 to $7\frac{1}{2}$ feet without tops.

Girth— $3\frac{1}{2}$ " to 4".

Internodes— $3\frac{1}{2}$ " to $4\frac{1}{2}$ ".

Aerial Roots—Few or none.

Buds—Round; fairly prominent; slightly pointed; covered by a light *kháki* fibrous covering.

DR. LEATHER'S *Analysis*—

		Poona Farm Crop.	
		1896.	1897.
Percentage of juice to cane	...	65.70	68.75
Do. of sugar to juice	...	14.71	14.10
Do. of glucose in juice	...	0.99	1.40

Variety—**Rasda'li**; **Rasva'li**; **Rasa'li**; that is, juicy.

Where grown—Haliál, Kánara District.

General Appearance—A tall, fairly hard, yellow green cane of moderate thickness.

Type—A.

Bloom—Little or none.

Nodes—Ring N_1 —Distinct; narrow; varies in colour; mostly green or yellow.

Band N_2 —Wide; fairly regular in width; root dots numerous and distinct.

Band N_3 —Wide; distinct; blue grey in colour.

Height—7 to $7\frac{1}{2}$ feet without tops, when well grown.

Girth— $3\frac{1}{4}$ " to $3\frac{3}{4}$ ".

Internodes—5" to 6".

Buds—Small; prominent; rounded; covered by brown or *kháki* scales.

DR. LEATHER'S *Analysis*—

		Poona Farm Crop.	
		1896.	1897.
		(Fresh imports.)	(Acclimatised 1 year.)
Percentage of juice to cane	...	60.40	62.14
Do. of sugar to juice	...	13.18	15.30
Do. of glucose in juice	...	1.49	1.00

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RASDÁLI;
RASVÁLI;
RASÁLI.

SACCHARUM:
Sugar.
Cultivation of Sugarcane in the
VARIETIES
OF CANE
EXAMINED.
YELLOW
GREEN.
Variety—Yellow Green.
Where grown—Bijápur; Bágalkot.

General Appearance—A yellow green cane; fair in length and thickness; slightly scored with brown; lower internodes not so thick as those in middle of cane.

Type—A; sometimes C; internodes very slightly bulged.

Bloom—A little.

Nodes—Ring N₁—Distinctly marked in upper nodes but not so distinct on the lower ones; varies in colour, but commonly part of ring, bright brown.

 Band N₂—Distinctly marked; pale green and yellow in colour; root dots very distinctly marked.

 Band N₃—Very distinct and regular; of blue grey colour.

Height—8 to 8½ feet without tops, when well grown.

Girth—4" to 4½".

Internodes—Very regular in length 4½" to 5".

Aerial Roots—None.

Buds—Small; rounded; pointed; covered with *lháki* coloured scales.

DR. LEATHER'S Analysis—

	Poona	Farm	Crop.	
	(Bijápur Yellow Green.)		(Bágalkot Yellow Green.)	
	1896.	1897.	1896.	1897.
	(Fresh imports.)	(Acclimatized 1 year.)	(Fresh imports.)	(Acclimatized 1 year.)
Percentage of juice to cane ...	70.40	70.62	68.40	68.75
Do. of sugar to juice ...	14.30	16.60	12.34	16.20
Do. of glucose in juice .	1.57	1.10	1.94	1.40

HULLU
KABBU.
Variety—Hullu Kabbu (*Hullu* = grass and *Kabbu* = sugarcane.)

Where grown—Southern Marátha Country.

General Appearance—A very thin, tall, hard cane; yellow green in colour; generally bent towards the top; many dirty patches; cane securely enclosed in dead side leaves; tillers freely; ratoons well.

Type—Generally B.

Bloom—Good deal.

Nodes—Ring N₁—Orange yellow, tinged with green on upper nodes.

 Band N₂—Dull yellow; root dots distinct.

Band N — Grey.

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Sugar.

VARIETIES
OF CANE
EXAMINED.

Height—7 to 8 feet ; some canes 10 feet without tops, when well grown.

Girth— $1\frac{3}{4}$ " to 2".

Internodes—5" to 7".

Aerial Roots—A few on lower nodes only.

Buds—Slightly prominent ; elliptical ; lower buds covered by brown scales ; upper ones light green in colour.

DR. LEATHER'S *Analysis*—

	Poona Farm Crop.		Belgaum Crop.
	1896. (Fresh imports.)	1897. (Acclimatized 1 year.)	1896. (Local.)
Percentage of juice to cane ...	52.60	56.17	55.90 to 59.80
Do. of sugar to juice ...	16.06	16.90	14.27 to 14.92
Do. of glucose in juice ...	A trace only.	0.70	A trace to 0.74

Variety—**Yellow Green.**

Where grown—Ránebennur, Dhárwár District ; and Chikodi, Belgaum District.

General Appearance—A light green or yellow cane ; moderately thick ; fairly tall and soft.

Type—A ; sometimes C ; internodes slightly bulged ; nodes not prominent.

Bloom—Some.

Nodes—Ring N₁—Distinctly marked ; narrow ; dull orange brown in colour, which, however, varies in lower nodes.

Band N₂—Distinctly marked ; wide ; root dots distinct and numerous.

Band N₃—Distinct ; wide ; dull grey in colour.

Height— $6\frac{1}{2}$ to 7 feet without tops, when well grown.

Girth—3" to 4".

Internodes—3" to 5".

Aerial Roots—None.

Buds—Small ; round or oval ; blunt ; covered by dull *kháki* scale-like covering, which gets fibrous on lower buds.

DR. LEATHER'S *Analysis*—

	Poona	Farm	Crop.
	(Chikodi Yellow Green.) 1896. (Fresh imports.)	1897. (Acclimatized 1 year.)	(Ránebennur Cane.) 1896. (Fresh imports.)
Percentage of juice to cane ...	65.50	68.47	64.10
Do. of sugar to juice ...	11.35	14.90	12.04
Do. of glucose in juice...	1.80	1.90	1.48

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YELLOW
GREEN.

**SACCHARUM :
Sugar.**
Cultivation of Sugarcane in the
**VARIETIES
OF CANE
EXAMINED.**
**SANNA
BILE
KABBU.**

Variety—**Sanna Bile Kabbu** (*Sanna* = small, *Bile* = white, *Kabbu* = sugarcane.)

Where grown—Khánápur ; Southern Marátha Country.

General Appearance—A tall, straight, yellow cane, tinged irregularly with pale green with vertical red brown scores at lower end ; characteristic bright orange red colouring on leaf sheaths of upper leaves ; dry leaves closely enclose the cane ; many dirty patches on cane ; tillers freely, and ratoons well.

Type—B.

Bloom—A little.

Nodes—Ring N_1 —Very distinct ; deep yellow ; fairly narrow.

Band N_2 —Cream colour well marked ; root dots fairly distinct.

Band N_3 —Distinct ; light blue, grey colour.

Height— $8\frac{1}{2}$ to 10 feet without tops, when well grown.

Girth— $3\frac{1}{4}$ " to 4" ; uniform.

Internodes—4" to $4\frac{1}{2}$ ".

Aerial Roots—Hardly any.

Buds—Small, rounded, and prominent ; lower buds *kháki* coloured ; upper buds pale yellow and green.

DR. LEATHER'S <i>Analysis</i> —	Poona Farm Crop.		Khánápur Crop.
	1896.	1897.	1896.
	(Fresh imports.)	(Acclimatized 1 year.)	(Local.)
Percentage of juice to cane ...	60.00	58.20	58.20
Do. of sugar to juice...	17.38	16.00	13.31
Do. of glucose in juice ...	0.68	0.90	1.09

**RED OR
PURPLE
MAURITIUS.**

Variety—**R or Purple Mauritius.**

Where grown—Imported in 1893 by the Bombay Agricultural Department.

General Appearance—A tall, thick, hard cane ; general colour purple, or bright purple on lower internodes ; the colouring gets lighter and brighter towards the upper internodes ; distinct, almost black, vertical stripes in most of the internodes resembling streaked cane ; the cane has a shining appearance ; leaves sometimes variegated in colour ; tillers freely ; inclined to flower, also to produce side shoots prematurely.

Type—A.

Bloom—None.

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Bombay Presidency.

(James Mollison.)

SACCHARUM:
Sugar.VARIETIES
OF CANE
EXAMINED.

Nodes—Ring N_1 —Very distinct, and except in lower nodes of cream colour.

Band N_2 —Colour variable but always lighter than the general colour of the cane; mostly dull yellow irregularly tinged with red or purple; root dots very distinct; each dot surrounded by a light coloured circle.

Band N_3 —Very distinct; dull blue grey in colour.

Height—8 to 9 feet without tops.

Girth—4" to 4½"; uniform.

Internodes—4½" to 6".

Aerial Roots—Few or none.

Buds.—Small; round; covered by a shining scale covering; light colour on the upper nodes, and dull purple on the lower one.

DR. LEATHER'S *Analysis*—

Poona Farm Crop.

1896. 1897.

Percentage of juice to cane	...	...	...	...	66.75	65.47
Do. of sugar to juice	...	...	...	...	12.88	12.50
Do. of glucose in juice	...	...	...	...	1.62	1.50

Variety—**Purple Cane.**

Where grown—Bijapur; Bassein, Thána District.

General Appearance—A fairly tall and moderately thick cane; lower internodes dull purple, irregularly scored vertically with dull *khaki* colour; upper internodes lighter in colour, with a streaked appearance; slightly resembling streaked cane.

Type—E.

Bloom—None.

Nodes—Ring N_1 —Indistinct; of variable colour; upper nodes pale yellow; lower ones dull purple.

Band N_2 —Pale yellow in upper nodes; pale dull and brown and purple in lower ones.

Band N_3 —Very distinct; light blue grey in colour.

Height—7 to 8 feet without tops, when well grown.

Girth—3½" to 4"; lower internodes considerably smaller in diameter than the middle ones.

Internodes—3½" to 5".

Aerial Roots—Very few or none.

Buds—Narrow; long; pointed; covered with fibrous scalelike covering; upper buds inclined to shoot early.

PURPLE
CANE.

SACCHARUM:
Sugar.

Cultivation of Sugarcane in the

VARIETIES
OF CANE
EXAMINED.

DR. LEATHER'S <i>Analysis</i> —		Poona	Farm	Crop.	
		(Bijápur Purple Cane.)		(Bassein Purple Cane.)	
		1896.	1897.	1896.	1897.
		(Fresh imports.)	(Acclimatized 1 year.)	(Fresh imports.)	(Acclimatized 1 year.)
Percentage of juice to cane	...	63·00	62·50	57·10	64·80
Do. of sugar to juice	...	13·27	13·80	13·31	13·60
Do. of glucose in juice	...	1·33	1·00	1·22	1·70

KARE
KABBU.*Variety*—**Kare Kabbu** (*Kare*=black, *Kabbu*=sugarcane.)*Where grown*—Belgaum, Khánápur, Belgaum District; and Ránebennur, Dhárwár District.*General Appearance*—A dark purple cane of fair length, and moderately thick; the general colour is tinged with green towards top, where cane is immature; ratoons fairly well.*Type*—E, but only slightly zig-zag.*Bloom*—None.*Nodes*—Ring N₁—Distinct; varies in colour similarly to Band N₂.Band N₂—Light purple or yellow green at upper end of cane; purple at lower end; root dots distinct.Band N₃—Blue grey.*Height*—6 to 7½ feet without tops, when well grown.*Girth*—3¼" to 3¾".*Internodes*—3" to 4".*Buds*—Dull *kháki* or light brown in colour; medium in size; oval.DR. LEATHER'S *Analysis*—

		Poona Farm Crop.			Belgaum, Khánápur and Ránebennur Crop.
		(Belgaum Cane.)	(Khánápur Cane.)	(Ránebennur Cane.)	(Local.)
		1896.	1896.	1896.	1896.
Percentage of juice to cane	...	60·70	63·00	54·40	60·70 to 66·00
Do. of sugar to juice	...	11·67	6·13	10·27	13·32 to 16·67
Do. of glucose in juice	...	1·54	2·57	1·60	0·85 to 1·17

RÁMRASDÁLI.

Variety.—**Ra'mrasda'li**.*Where grown*—Haliál, Kánara District.*General Appearance*—A fairly tall soft cane; uniform in thickness; irregularly streaked with dull purple and pale green streaks, varying very irregularly in width; ratoons fairly well.

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Bombay Presidency.

(James Mollison.)

SACCHARUM:
Sugar.VARIETIES
OF CANE
EXAMINED.

Type—A and E combined; only slightly zigzag; internodes slightly bulged sometimes.

Bloom—A little.

Nodes.—Ring N_1 —Fairly distinct; varies in colour.

Band N_2 —Regular in shape; not distinctly marked; root dots fairly distinct.

Band N_3 —Distinct; light blue-gray in colour.

Height—7 to 8 feet without tops.

Girth— $3\frac{1}{4}$ " to 4"; regular throughout.

Internodes—5" to 7".

Aerial Roots—None or few.

Buds—Fair sized; rounded; pointed; covered by fibrous brown scales.

DR. LEATHER'S Analysis —

	Poona Farm Crop.
	1896. 1897.
	(Fresh (Acclimatized
	imports.) 1 year.)

Percentage of juice to cane	...	...	70.10	63.70
Do. of sugar to juice	...	...	8.22	14.50
Do. of glucose in juice	...	...	2.41	0.80

Variety—Streaked Cane.STREAKED
CANE.

Where grown—Gadag, Dhárwār District; also Belgaum and Khánápur, Belgaum District.

General Appearance—A tall, thick, soft cane; irregularly streaked in purple and green or pale purple and yellow colours; streaks not so distinct as in *Rámrasdáli*.

Type.—C and E combined; but internodes only slightly bulged and cane only slightly zig-zag in appearance.

Bloom—Good deal.

Nodes.—Ring N_1 —Fairly well marked; varying in colour; upper nodes yellow; lower nodes irregular in colour.

Band N_2 —Irregular; also varies in colour; root dots very distinct but small.

Band N_3 —Distinct; light blue-grey coloured.

Height—7 to 8 feet without tops.

Girth—4" to $4\frac{1}{2}$ "; thick canes 5".

Internodes—4" to 5"; lower internodes slightly smaller in diameter than the middle ones.

Aerial Roots—None.

SACCHARUM:
Sugar.

Cultivation of Sugarcane in the

VARIETIES
OF CANE
EXAMINED.*Buds*—Fairly large; pointed; prominent; covered with *kháki* coloured scales.DR. LEATHER'S *Analysis*—

		Poona Farm Crop (Streaked Cane from Gadag.) 1896. (Fresh imports.)	1897. (Acclimatized 1 year.)	Belgaum, Khánápur, and Gadag Crop (Local.) 1896.
Percentage of juice to cane	...	70.20	69.86	71
Do. of sugar to juice	...	8.87	14.50	14.55 to 17.37
Do. of glucose in juice	...	2.12	0.50	0.79 to 1.39

(B.)—VARIETIES OUTSIDE THE BOMBAY PRESIDENCY.

(Examined by DR. LEATHER.)

MADRÁSI
POUNDA.*Variety*—**Madra'si Pounda.***Where grown*—Sitápur; Bára Banki; Bareilly.*General Appearance*—A thick, orange, yellow to green straight cane; this is a very erect strong cane, harder outside than most *Poundas*; little liable to crack lengthwise or to fall down; it gives about 70 per cent. of juice and has about 15 to 16 per cent. of sugar in the juice (*vide* Cawnpore Farm Experiments).*Type*—A; frequently C.*Bloom*—None.*Nodes*—Ring N₁—Generally indistinct or absent.Band N₂—Drab or green; root dots prominent.Band N₃—Distinct; gray coloured.*Height*—5 to 8 feet.*Girth*—4" to 4 $\frac{3}{4}$ ".*Internodes*—3 $\frac{1}{2}$ " to 5".*Aerial Roots*—Common; they grow from one node to the other like the Sháháranpuri *Pounda*.*Dry Leaves*—Generally open out.

SAMSÁRA.

Variety—**Samsa'ra.***Where grown*—Dumraon; Burdwán.*General Appearance*—A yellow green cane; frequently lemon-yellow, or orange coloured where exposed to sunlight; erect.*Type*—C; sometimes A.*Bloom*—Very little; no scorings.*Nodes*—Ring N₁—Narrow; indistinct.Band N₂—Orange or yellow green; root dots distinct.Band N₃—Well defined; gray.

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Bombay Presidency.

(J. W. Leather.)

SACCHARUM:
Sugar.VARIETIES
OF CANE
EXAMINED.*Height*—4 to 6 feet at Dumraon; 8' to 12' feet at Burdwán.*Girth*— $3\frac{1}{2}$ " to 4".*Internodes*— $3\frac{1}{2}$ " to $4\frac{1}{2}$ ".*Aerial Roots*—Many; they grow from one node to the next below in a very characteristic manner.*Buds*—Large; groove narrow deep.*Dry Leaves*—Open out from cane.DR. LEATHER'S *Analysis*—

	Dumraon Castor cake plot.	Farm Crop. Cattle- dung plot.	Burdwan. Castor cake plot.	Farm Crop. Cattle-dung plot.	Village Kantal- gachi.	Village Banpata.	Village Hartsimal.
Percentage of juice to cane ...	...	...	...	...	71.80	73.20	67.70
Percentage of sugar to juice ...	12.35	15.36	14.24	14.24	15.24	15.24	15.24
Percentage of glu- cose in juice ...	1.34	0.72	1.86	1.86	1.86	1.86	1.86
Specific gravity at 15.5°C.	1,067	1,074	1,075	1,075	1,079	1,078	1,078

Variety—Sha'ha'ranpuri.*Where grown*—Cawnpore and Bareilly.*General Appearance*—Yellow-green coloured; straight; generally free from black patches at Cawnpore; but some patches found at Bareilly.*Type*—Generally C; less frequently A.*Bloom*—A little.*Nodes*—Ring N₁—Indistinct; green.Band N₂—Orange coloured; root dots very distinct.Band N₃—Blue gray.*Buds*—Very liable to shoot.*Height*—4 to 6 feet.*Girth*— $3\frac{1}{4}$ " to 4".*Internodes*—2" to 3"; sometimes 5".*Aerial Roots*—Very frequent throughout the whole length of cane and grow from one node to the other.*Dry Leaves*—Open out and expose the cane.DR. LEATHER'S *Analysis*—

	Cawnpore Crop.	Bareilly Crop.
Percentage of sugar to juice...	13.54	14.92
Percentage of glucose in juice	0.67	0.37
Specific gravity at 15.5°C. ...	1,066	1,070

SHÁHÁRAN-
PURI.

**SACCHARUM :
Sugar.**
Cultivation of Sugarcane in the
**VARIETIES
OF CANE
EXAMINED.**
KAJLI.

Variety—**Kajli.**

Where grown—Burdwan.

General Appearance—A purple cane ; straight.

Type—A or D.

Bloom—Good deal.

Nodes—Ring N_1 —Indistinct ; yellow or purple.

Band N_2 —Generally yellow on upper part ; purple on lower end ; root dots prominent.

Band N_3 —Distinct ; gray.

Height—6 to 8 feet.

Girth—3".

Internodes—3" to $3\frac{1}{2}$ ".

Aerial Roots—Many ; halfway up the cane.

DR. LEATHER'S Analysis—

	Village Hartsimal.	Village Kantalgachi.	Village Banpata.
Percentage of juice to cane ...	66.00	68.10	68.00
Do. of sugar to juice ...	17.05	17.05	17.05
Do. of <i>Gur</i> to cane ...	13.00	13.0	13.00
Do. of glucose in juice...	1.54	1.54	1.54
Specific gravity at 15.5°C. ...	1,083	1,080	1,080

**PURPLE
POUNDA.**

Variety—**Purple Pounda.**

Where grown—Bára Banki ; Bareilly.

General Appearance—Sometimes reddish purple, sometimes very dark purple.

Bloom—Only on the Band N_3 below the nodes.

Height—5 to 7 feet.

Girth— $3\frac{1}{2}$ " to $4\frac{1}{2}$ ".

Internodes—3" to $4\frac{1}{2}$ ".

Aerial Roots—Sometimes at lower end.

Dry Leaves—Fall off.

MUNGO.

Variety—**Mungo.**

Where grown—Dumraon.

General Appearance—Yellow-green coloured ; straight ; seldom scored, and with no black patches ; very like *Bhurli* but the leaves are of a lighter green colour and are soft and crumple up.

Type—B.

Bloom—Much.

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(J. W. Leather.)

SACCHARUM:
Sugar.

VARIETIES
OF CANE
EXAMINED.

Nodes—Ring N_1 —Indistinct and drab.

Band N_2 —Drab; root dots not very distinct.

Band N_3 —Indistinct.

Height—5 to 7 feet.

Girth—2" to $2\frac{1}{2}$ ".

Internodes— $3\frac{3}{4}$ " to $4\frac{1}{2}$ ".

Aerial Roots—None.

Buds—Small.

Dry Leaves—Remain folded.

DR. LEATHER'S Analysis—

Dumraon Farm Crop, 1897.
Castor cake plot. Cattle-dung plot.

Percentage of sugar to juice	...	...	11.73	13.53
Do. of glucose in juice	...	...	1.18	0.46
Specific gravity at 15.5°C}.	...	...	1.053	1.064

Variety—**Bhurli**.

BHURLI

Where grown—Dumraon.

General Appearance—A short yellow-green coloured cane; straight and of uniform thickness; black patches infrequent; scoring infrequent; very like *Mungo*; the canes of these two varieties are almost indistinguishable, but the green leaves are quite distinct; those of *Bhurli* are deeper green and not soft and crumpled up like *Mungo*.

Type—B.

Bloom—Considerable.

Nodes—Ring N_1 —Indistinct; drab.

Band N_2 —Drab; green; root dots distinct.

Band N_3 —Indistinct; gray.

Height—4 to 6 feet.

Girth—2" to $2\frac{3}{4}$ ".

Internodes— $3\frac{1}{2}$ ".

Aerial Roots—None.

Dry Leaves—Sometimes open out; sometimes remain folded.

DR. LEATHER'S Analysis—

Dumraon Farm Crop.
Castor cake plot. Cattle-dung plot.

Percentage of sugar to juice	...	...	13.76	16.09
Do. of glucose in juice	...	...	0.70	0.23
Specific gravity at 15.5°C}.	...	...	1.067	1.074

SACCHARUM:
Sugar.

VARIETIES
OF CANE
EXAMINED.
PANSÁ'BI.

Cultivation of Sugarcane in the

Variety—**Pansa'bi.**

Where grown—Behea.

General Appearance—A cane taller than the *Mungo* and *Bhurli* with which it is grown; green and yellow-green coloured; erect; black patches frequent.

Type—D.

Bloom—Not much.

Nodes—Ring N_1 —Indistinct; narrow; orange.

Band N_2 —Drab coloured; root dots indistinct.

Band N_3 —Gray.

Height—4 to 6 feet.

Girth—2" to $2\frac{1}{2}$ ".

Internodes—2" to 4".

Aerial Roots—Common at lower end.

Buds—Small and round.

Dry Leaves—Open out from cane.

DR. LEATHER'S *Analysis*—

Percentage of juice to cane	...	...	...	53.50
Do. of sugar to juice	...	...	...	14.56
Do. of glucose in juice	...	...	...	0.44
Specific gravity at 15.5° C.	...	...	...	1.071

KHA'RI.

Variety—**Kha'ri.**

Where grown—Dumraon and Burdwan.

General Appearance—A tall thin, hard, yellow-green cane; sometimes pinkish coloured, where exposed; at Dumraon, quite straight; at Burdwan, much bent at upper end; frequently many black patches; scorings common.

Type—D.

Bloom—Much.

Nodes.—Ring N_1 —Very distinct; orange coloured.

Band N_2 —Narrow; drab; root dots indistinct.

Band N_3 —Not very distinct.

Height—6 to 8 feet.

Girth— $2\frac{1}{4}$ " to $2\frac{3}{4}$ ".

Internodes— $3\frac{1}{2}$ " to 5".

Aerial Roots—Some.

Buds—Large; groove very little developed.

Dry Leaves—Open out partly.

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(J. W. Leather.)

SACCHARUM:
Sugar.

DR. LEATHER'S <i>Analysis</i> —	Dumraon Farm Crop.		Burdwan Farm Crop.	
	Castor cake plot.	Cow-dung plot.	Cow-dung plot.	Cow-dung plot.
Percentage of juice to cane ...	...	...	...	61.80
Do. of sugar to juice ...	10.90	15.43	16.59	18.96
Do. of glucose in juice...	0.71	0.32	1.03	0.36
Specific gravity at 15.5°C. ...	1,059*	1,073	1,078	1,084

VARIETIES
OF CANE
EXAMINED.*Variety*—Puri.

PURI.

Where grown—Burdwan.*General Appearance*—A clean yellow or yellow-green cane; straight; no scorings.*Type*—B.*Bloom*—None.*Nodes*—Ring N₁—Fairly distinct; narrow; lemon-coloured.Band N₂—Cream coloured; root dots distinct.Band N₃—Very distinct; gray.*Height*—4 to 6 feet.*Girth*—2½".*Internodes*—2¾".*Aerial Roots*—Some.*Buds*—Small.DR. LEATHER'S *Analysis*—

Percentage of juice to cane ...	...	...	...	72.10
Do. of sugar to juice ...	...	...	...	18.02
Do. of <i>Gur</i> to cane ...	...	...	...	11.30
Do. of glucose in juice ...	...	...	...	0.76
Specific gravity at 15.5° C. ...	...	...	...	1.083

Variety—Dikchan.

DIKCHAN.

Where grown—Cawnpore; Sháhjahánpur.*General Appearance*—Yellow-green coloured; some black patches; inclined to grow crooked.*Type*—D.*Bloom*—A good deal.*Nodes*—Ring N₁—Distinct and very broad; sometimes as broad as the Band N₂.Band N₂—Yellow or green coloured; root dots very prominent.Band N₃—Blue-gray.

* Much laid.

SACCHARUM:
Sugar.

Cultivation of Sugarcane in the

VARIETIES
OF CANE
EXAMINED.

Height—8 to 10 feet.
Girth—2" to 2 $\frac{3}{4}$ ".
Internodes—4 $\frac{1}{2}$ " to 5".
Aerial Roots—Very frequent and extend a long way up the cane ; only at lower end at Sháhjahánpur.
Dry Leaves—Remain folded.
DR. LEATHER'S Analysis—
Percentage of sugar to juice 10.99
Do. of glucose in juice 0.49
Specific gravity at 15.5° C. 1.060

DHAUL;
DHAUR.

Variety—**Dhaul; Dhaur.**
Where grown—Cawnpore ; Bareilly ; Sháhjahánpur.
General Appearance—Mainly drab coloured, but tinged with green at the top and bottom ends ; scored longitudinally.
Type—B.
Bloom—Good deal.
Nodes—Ring N₁—Distinct ; orange coloured or brick red ; frequently broader at one side than at the other.
Band N₂—Drab or green coloured ; root dots distinct and prominent.
Band N₃—Gray coloured.
Height—6 to 8 feet.
Girth—2" to 2 $\frac{1}{4}$ ".
Internodes—5" to 6".
Aerial Roots—Occasionally at lower end.
Dry Leaves—Remain folded tight.
DR. LEATHER'S Analysis—
Percentage of sugar to juice 13.32
Do. of glucose in juice 0.57
Specific gravity at 15.5° C. 1.066

MATNA.

Variety—**Matna.**
Where grown—Cawnpore and Sháhjahánpur.
General Appearance—Green and drab coloured ; fairly straight, but the tall ones bent at the top ; scored longitudinally ; black patches infrequent.
Type—B ; sometimes C.
Bloom—Good deal.

Bombay Presidency.

(J. W. Leather.)

SACCHARUM :
Sugar.VARIETIES OF
CANE
EXAMINED.*Nodes*—Ring N_1 —Orange coloured and moderately distinct.Band N_2 —Drab; root dots very distinct.Band N_3 —Very indistinct.*Height*—7 to 8 feet.*Girth*—2" to $2\frac{1}{4}$ " at Cawnpore; 2" to 3" at Sháhjahánpur.*Internodes*—4" at Cawnpore; 2" to 3" at Sháhjahánpur.*Aerial Roots*—None.*Dry Leaves*—Remain folded.DR. LEATHER'S *Analysis*—

Percentage of sugar to juice	...	...	...	13.36
Do. of glucose in juice	...	...	...	0.77
Specific gravity at 15.5° C. ...	...	...	...	1.067

Variety—**Pansa'bi.**

PANSÁBI.

Where grown—Gorakhpore.*General Appearance*—A pale green to yellow cane; straight; inclined to sprout at upper end. This is probably not the same as the *Pansábi* grown at Behea.*Bloom*—Some.*Height*—6 feet.*Girth*— $2\frac{3}{4}$ ".*Internodes*— $4\frac{1}{2}$ " to 5".*Aerial Roots*—None.*Dry Leaves*—Remain folded.*Variety*—**Chuni.**

CHUNI.

Where grown—Bareilly, Sháhjahánpur.*General Appearance*—Mostly yellow, with pale-green; very like *Rákra*; but the internodes are longer and the Band N_3 is much darker.*Type*—B.*Bloom*—Good deal.*Nodes*—Band N_3 —Distinct; blue-gray.*Height*—4 to 6 or 7 feet.*Girth*—2" to $2\frac{1}{2}$ ".*Internodes*—4" to 6".*Aerial Roots*—Common at lower end.

SACCHARUM:
Sugar.

Cultivation of Sugarcane in the

VARIETIES OF
CANE
EXAMINED.
SARAUTI.

Variety—**Sarauti.**

Where grown—Bára Banki.

General Appearance—A white cane; bluish coloured at nodes.

Bloom—A little.

Height—3 to 4 feet.

Girth— $1\frac{1}{2}$ " to $2\frac{1}{2}$ ".

Internodes— $2\frac{1}{2}$ " to 3".

Aerial Roots—Infrequent.

KASWÁR

Variety.—**Kaswa'r.**

Where grown—Bára Banki.

General Appearance—A bluish white coloured cane; straight.

Bloom—Some.

Height—3 to 5 feet.

Girth— $1\frac{3}{4}$ " to $2\frac{1}{4}$ ".

Internodes— $2\frac{1}{2}$ " to 3".

Aerial Roots—None.

Dry Leaves—Remain folded tight.

KITÁVA.

Variety—**Kita'va.**

Where grown—Sháhjahánpur and Bára Banki.

General Appearance—A pale yellow to green cane.

Bloom—Fair amount, especially at nodes.

Nodes—Almost colourless and smooth.

Height—4 feet.

Girth—2" to $2\frac{3}{4}$ ".

Internodes—3" to 4".

Aerial Roots—A little at lower end.

An experiment made by Mr. RICKETTS, Special Manager of Court of Wards' Estates, Bára Banki, on 728 sq. feet gave the following result. It is equal to an outturn of 2,154 lbs. *Gur* per acre. The land was unirrigated alluvium:

					lbs.
Cane	...	...	...	...	500
Juice	...	...	...	...	310
<i>Gur</i>	...	...	...	...	36
Percentage of juice to cane	...	...	...	...	62.0
Do. of <i>Gur</i> to cane	...	...	...	...	7.2

Bombay Presidency.

(J. W. Leather.)

SACCHARUM:
Sugar.

VARIETIES OF
CANE
EXAMINED.
REHRA.

Variety—**Rehra.**

Where grown—Gorakhpore.

General Appearance—A pale yellow cane; inclined to sprout at the top end.

Bloom—Some.

Nodes—Smooth.

Height—5 feet.

Girth—2 $\frac{3}{4}$ ".

Internodes—2" to 3 $\frac{1}{2}$ ".

Aerial Roots—None.

Dry Leaves—Open out more or less.

Variety—**Rámwie.**

Where grown—Sitápur, Bára Banki.

General Appearance—A yellow cane with pink patches; smooth and straight; does not sprout.

Bloom—Much.

Nodes—Smooth, with orange ring above them.

Height—4 to 6 feet.

Girth—1 $\frac{1}{2}$ " to 2".

Internodes—3" to 6".

Aerial Roots—Common at lower end

Dry Leaves—Remain folded.

RÁMWIE.

The following figures were obtained in experiments made by Messrs. MARTIN and RICKETTS, Special Managers, Court of Wards' Estates, Sitápur and Bára Banki. Mr. MARTIN's test was taken on $\frac{1}{32}$ acre and shows an outturn of 1,824 lbs. *Gur* per acre; Mr. RICKETTS' was on 1,029 square feet, and is equal to 2,370 lbs. *Gur* per acre.

	Mr. MARTIN's test (Sitápur.)	Mr. RICKETTS' test (Bára Banki.)
	lbs.	lbs.
Cane	798	500
Juice	420	289
<i>Gur</i>	57	56
Percentage of juice to cane	52.6	57.8
Do. of <i>Gur</i> to cane	7.1	11.2

SACCHARUM:
Sugar.

Cultivation of Sugarcane in the

VARIETIES OF
CANE
EXAMINED.
PARRÁRAH.*Variety*—**Parra'rah.***Where grown*—Sitápur.*General Appearance*—A straw-yellow to pale-green coloured cane; fairly straight.*Bloom*—Good deal of pale blue.*Nodes*—Dark-green above node.*Buds*—Inclined to sprout.*Height*—5 to 6 feet.*Girth*— $2\frac{1}{2}$ " to $2\frac{3}{4}$ ".*Internodes*—3" to $4\frac{1}{2}$ ".*Aerial Roots*—None.*Dry Leaves*—Remain folded tight.

A test made by Mr. MARTIN, Special Manager of 'Court of Wards' Estates, gave the following outturn on $\frac{1}{32}$ acre, which is equal to 2,848 lbs. *Gur* per acre.

						lbs.
Cane	...	...	...	...	...	1,063
Juice	...	...	...	...	...	577
<i>Gur</i>	...	...	...	...	...	89
Percentage of juice to cane	...	...	...	...	...	54.2
Do. of <i>Gur</i> to cane	...	...	...	...	...	8.3

KÁRWIE.

Variety—**Karwie.***Where grown*—Bára Banki.*General Appearance*—A pale-yellow cane; thinner at lower end than at upper end. This cane appears to be similar to *Chuni*.*Bloom*—A good deal.*Nodes*—Smooth; Ring N₁ distinct and orange-yellow coloured.*Height*—3 to 5 feet.*Girth*— $1\frac{3}{4}$ " to 2".*Internodes*—3" to 5".*Aerial Roots*—Some at lower end.*Dry Leaves*—Remain folded tight.

THUN.

Variety—**Thun.***Where grown*—Sháhjahánpur.*General Appearance*—A yellow-green cane; much inclined to sprout along its whole length; straight.

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(J. W. Leather.)

SACCHARUM:
SUGAR.VARIETIES
OF CANE
EXAMINED.*Bloom*—None.*Height*—4 to 5 feet.*Girth*— $3\frac{3}{4}$ " to 4".*Internodes*— $2\frac{1}{2}$ " to $3\frac{1}{2}$ ".*Variety*—Munga.*Where grown*—Bára Banki.*General Appearance*—A yellow and bright green coloured cane; straight.*Bloom*—Hardly any.*Height*—6 to 7 feet.*Girth*— $1\frac{1}{2}$ " to 2".*Internodes*—4" to 6".

MUNGA.

Variety—Munga.*Where grown*—Sháhjahánpur.*General Appearance*—A bright green coloured cane; inclined to grow crooked. It is doubtful whether this is the same variety as that called *Munga* at Bára Banki.*Type*—D.*Bloom*—Hardly any.*Height*—6 feet.*Girth*—2" to $2\frac{1}{4}$ ".*Internodes*— $2\frac{1}{4}$ " to 4".*Aerial Roots*—Common for $\frac{3}{4}$ of the whole length.

MUNGA.

Variety—Ra'kra.*Where grown*—Sháhjahánpur.*General Appearance*—Colour almost white.*Type*—B.*Bloom*—A little.*Nodes*—Ring N₁ distinct; yellow.*Height*—7 feet.*Girth*—2" to $2\frac{1}{4}$ ".*Internodes*— $2\frac{1}{2}$ " to $3\frac{1}{2}$ ".*Aerial Roots*—None.*Dry Leaves*—Remain folded tight.

RAKRA.



(Agricultural Series, No. 26.)
(Fibres.)

THE AGRICULTURAL LEDGER.

1898—No. 9.

GOSSYPIMUM SP.
(EGYPTIAN COTTON.)

[*Dictionary of Economic Products, Vol. IV., G. 381.*]

EXPERIMENTAL CULTIVATION OF EGYPTIAN COTTON IN RADHANPUR.

A Memorandum by MAJOR M. T. LYDE, I.S.C., Administrator, Radhanpur State.

From time to time interest has been aroused in the subject of the cultivation in India of Egyptian cotton. The several experiments which have been carried out in India with Egyptian cotton seed have not perhaps on the whole been always favourable in their results. To those, however, who have occupied themselves in similar operations, the following brief account of Egyptian cotton experiments conducted in the Radhanpur State is, it is considered, sufficiently interesting to warrant its publication in *The Agricultural Ledger*. The paper has been obligingly furnished by Major Lyde, under whose supervision the work was initiated.

The two varieties of Egyptian cotton now being experimented with are "Zafiri" and "Abassi." "Zafiri" cotton is named after its discoverer, Mr. Zafiri Parachimonas; while the name "Abassi" is derived from Wadi Abassi on the east bank of the Blue Nile, or Dar Sennar, a subdivision of Upper Nubia. Egyptian cotton is known for its good colour and long staple, and finds a ready outlet on European markets.

Experimental cultivation of Egyptian varieties of cotton has been undertaken at the Government Agricultural Farms during the past

PREFATORY
REMARKS.

Zafiri and
Abassi
Cotton.

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GOSSYPIUM
sp.

Experimental Cultivation of

EGYPTIAN COTTON CULTIVA- TION. Nagpur.	year or two. At Nagpur the quality of the Cairo cotton was pronounced to be excellent and gave a yield of about double the value of the ordinary kinds. So successful was the experiment that large sowings were made in 1897, and if the results are satisfactory there will be a big demand for Egyptian cotton seed. It is recommended to be grown as a <i>rabi</i> crop and, if necessary, irrigated.
Cawnpur.	At Cawnpur the fact was discovered that several varieties of cotton were capable of yielding successive outturns of fibre and seed if the plants were, instead of being cut down at the completion of the first picking, allowed to stand in the field. Major Lyde, at Radhanpur, obtained good results by allowing the plants to grow up again from the shoots after they had been cut down at the termination of the first crop. It would be very important to show the relative economy of these two methods.
Radhanpur. Quantity of seed sown.	<p>EGYPTIAN COTTON :—One maund of Egyptian cotton seed of which about thirty pounds were sown was received from Bombay. The seed was sown in a measured acre of land which, although favourably situated close to Radhanpur Town and at a short distance from a large tank, was without a cultivator in consequence of the land being considered <i>khāra</i>, a term which in this State appears to refer not only to salt lands but also to impoverished ones. The land was well ploughed with a country plough and furrows were made at a distance of one yard from each other the breadth of the furrow included, which was about 10 inches, the depth being the same. The sowing was commenced on the 9th October 1896 eight or ten seeds being planted in the ground immediately under one side of the ridge and 12 to 14 inches apart. The whole was watered seventeen times and only the strongest plants left. The picking commenced on the 1st May 1897 and was completed by the 31st idem. As it is customary in this State to pick cotton with the husk, the cotton was so picked, and the weight reported by the official who superintended the picking was 806lb of kapás with the husks called here <i>kállā</i>. This had to be sent 15 miles to the ginning factory, and on arrival was found to weigh only 685lb. It, therefore, remains uncertain whether a portion of it was stolen or whether it was wrongly weighed in Radhanpur before despatch. At any rate there is no mistake about the result of the ginning which gave 185$\frac{3}{4}$lb</p>
Land how prepared.	
Date of sowings.	
Of gathering.	
Result of the picking.	
Of ginning.	

Egyptian Cotton in Radhanpur. (M. T. Lyde)

GOSSYPIMUM
sp.

EGYPTIAN
COTTON
CULTIVA-
TION.

An opinion
on season
for sowing.

Second crop.

Date of first
picking.

Result of the
picking.

Important
fact which
it seems
desirable to
establish.

of cleaned cotton and 322lb of seed. In this State cotton is sown during the rains which ordinarily last from the middle or end of June to the middle of September with perhaps a few showers later on. In sowing in October I followed a suggestion contained in a pamphlet I received from Mr. Tata, a gentleman of Bombay interested in cotton and who was good enough to procure the seed for me. In this pamphlet he pointed out that the proper season for sowing was a point yet to be ascertained, and with a view to decide this I determined to leave the cotton shrubs in the ground. I had the shrubs cut down therefore and manured with town sweepings before the commencement of the rains of 1897 which were very late, the first rain falling on the 16th of July. On the 13th December 1897 the first picking of the second crop was commenced and up to date the whole of the cotton has not been picked as there are still pods and a few flowers on the shrubs. As, however, I am leaving Radhanpur for a time I give the result of the experiment up to date. At the first picking of this second crop the husks were picked with the kapás and the weight with the husks was 156lb which represents not less than 42lb of cleaned cotton. Since then only the kapás has been picked leaving the husk on the shrubs and up to date 295lb of kapás have been picked beside that picked with the husk, the same ratio of cleaned cotton to seed as was found to exist by the result of the experiment of 1896 gives 108lb of cleaned cotton. This then added to the 42lb above referred to gives a total of 150lb of cleaned cotton, and, as I have already stated, the pickings have not been completed. Since the commencement of the ripening of the pods in 1897, that is to say, since the 20th of April 1897, no water has been given. In about a month's time when the pickings have been completed the shrubs will be again cut down and the ground manured with town sweepings, and it is believed that the plants will survive the hot weather without being watered and again bear fruit after the rains, and I am anxious to establish the fact that a cultivator may, if he is able to irrigate the first sowing, always have, say, 15 acres of cotton under cultivation and only have to plough and prepare 5 acres a year, and this would enable him to cultivate three times as much land for cotton per annum as he does now, with, so far as the preparation of the ground is concerned, the same

GOSSYPIUM
sp.

Experimental Cultivation of Egyptian Cotton in Radhanpur.

EGYPTIAN
COTTON
CULTIVA-
TION.Expert's
opinion on
this year's
picking.General
conclusions.

amount of labour as he at present expends on one-third of the area or better still he will be able to devote more time and care to the preparation of the soil for the new crop of five acres which he would sow yearly. This calculation is based on the assumption that after the third crop the cotton will deteriorate, but I know of no reason why this should be the case so long as the land is carefully weeded and manured. A sample of this year's picking I have submitted to Mr. Tata, and he has stated as his opinion that "the sample though not equal to the ordinary Egyptians, compares favourably with our best Indian varieties. The quality is fairly good and the staple longer and stronger than Broach. In value I believe it would fetch Rs 15 more per candy than good Broach." I shall request my successor to continue the experiment and this year to sow an acre during the rains at the same time as country cotton is ordinarily sown in this State, and to leave this without water through the following hot weather. I shall also request him to sow half an acre with the seed of this year's pickings.

From the above experiment the following results may be noted. The cotton leaves the seed quite clean when it is ginned, whereas in the indigenous varieties a certain portion clings to the seed. On page 61, section 468 of Vol. IV. of the *Dictionary of Economic Products of India*, the average yield of cleaned cotton per acre in the Bombay Presidency is shown to be 79.2lb, the yield of cleaned to seed cotton being taken as 30 : 100, whereas the result of my experiment has been to show that the ratio is with Egyptian cotton considerably higher, and that the outturn was in 1896, 185 $\frac{3}{4}$ lb, although the year was not particularly favourable and that up to date the yield this year may be taken as 150lb although the pickings are not finished and this year the condition of the ordinary cotton crops is bad. By raising the plants with the aid of irrigation at first and then leaving them in the ground there need be no anxiety regarding the rain as there now is, for when the seed is sown yearly if it cannot be sown either on account of want of, or of excessive rain, at the proper time the crop is a failure, and lastly that cotton when grown as in this experiment is able to resist a considerable quantity of salt in the land for on the land chosen for this experiment, after watering, a white efflorescence appears on the surface.

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G. I. C. P. O.—No. 142 R. & A.—12.9.98.—2,225.—H. R.

THE
AGRICULTURAL LEDGER.

1898—No. 10.



SILK.

(MULBERRY.)

[*Dictionary of Economic Products*, Vol. VI., Pl. III., S. 1822.]

SALE OF RAW SILK FOR THE KASHMIR DARBAR.

Official Papers including Memoranda on the Sale by SIR GEORGE BIRDWOOD, K.C.I.E., opinions of SIR THOMAS WARDLE, KT., and other experts consulted, etc.

The following papers on the subject of the sale of Kashmir silk in London afford information which it seems likely may be of interest to those engaged in the silk trade. They are accordingly published for information. The two Memoranda prepared by Sir George Birdwood, K.C.I.E., will be found to contain full details of the sales as well as the opinions of the brokers, merchants, manufacturers and special experts who were consulted. It will be observed that in his second Memorandum Sir George Birdwood expresses the opinion that given perfect reeling the prospect of Kashmir silk being sold at a profit in Europe is decidedly hopeful.

INTRODUC-
TORY.

***Memorandum on sale of raw Silk for the Kashmir Darbar,
24th February 1896.***

KASHMIR
SILK.

In July 1895, Mr. Walter Roper Lawrence, C.I.E., I.C.S., brought, on behalf of the Kashmir Darbar, some samples of raw mulberry silk to this office for valuation, in the London market. Mr. [now Sir] Thomas Wardle, of Leek, to whom the samples were referred by the Secretary of State in Council, reported most favourably on them, and his report was forwarded to the Government of India for transmission to the Kashmir Darbar, on the 5th of December

Sir George
Birdwood's
memoran-
dum.

S. 1822.

SILK :
Mulberry.

Sale of raw Silk

KASHMIR
SILK.Sir George
Birdwood's
memoran-
dum.Conf. pp. 5,
6.

1895. Mr. Wardle had in his report strongly advised that the stock of raw silk retained by the Darbar, pending the results of Mr. Wardle's examination of the samples drawn from it, should be shipped direct to London, and sold here, instead of being disposed of in the Calcutta market; and Mr. Lawrence, concurring in this advice, the Government of India were asked by telegraph on the 23rd of October 1895, to inform the Kashmir Darbar that it was desirable that the silk should at once be sent to London. On the 29th of November last Mr. R. Mukerji, the Director of Sericulture, Kashmir, wrote to me (see Appendix A) that, under the orders of the Darbar, sixteen cases of raw silk had been addressed to me for sale in London. These cases I duly received on the 28th of January this year, and four of them were at once opened, and samples drawn from each, and sent to various brokers, merchants, and manufacturers, including Mr. Thomas Wardle, who had undertaken to distribute samples of the silk beyond the range of possible purchasers commanded by myself. The sixteen cases contained silk of three qualities, in the following proportions:—

No. 1 quality	.	.	.	.	.	9 bales.
No. 2 „	.	.	.	.	.	3 „
No. 3 „	.	.	.	.	.	4 „

The tenders received were as follows:—

Tender 1.

Messrs. Henckell, Du Boisson & Co., 18, Laurence Pountney Lane, London, E.C., offered for the whole consignment, for—

					s.	d.
No. 1 quality	.	.	.	.	12	9 per pound.
No. 2 „	.	.	.	.	10	9 „
No. 3 „	.	.	.	.	10	9 „

Tender 2.

Messrs. William Milner & Sons, Leek, offered for the whole of—
No. 1 quality 12s. 6d. per pound.

Tender 3.

Messrs. Worthington & Co., Leek, offered for the whole of—
No. 3 quality 10s. per pound.
No offer for No. 2 quality other than that of Messrs. Henckell, Du Boisson & Co., was received.

The above three tenders were discussed at an informal meeting at the India Office on the 24th of February last, between Sir Charles S. 1822.

for the Kashmir Darbar.

SILK :
Mulberry.

Bernard, K.C.S.I., Mr. Lawrence, Mr. Rose, the Technical Assistant in the Revenue and Statistics Department here, and myself, when, for the reasons set forth in Mr. Lawrence's minute (Appendix B), the tender of the Messrs. Henckell and Du Boisson was accepted.

The following table shows the valuations put on the consignment under its three qualities, by four experts, and the three firms who tendered for it, in whole or in portions :—

KASHMIR
SILK.
Sir George
Birdwood's
memoran-
dum.

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7.

	No. 1 Quality.	No. 2 Quality.	No. 3 Quality.	REMARKS.
<i>Experts—</i>	Per lb	Per lb	Per lb	
1. Mr. Wardle	10s. 6d.	10s.	8s. 9d.	
2. Another silk manufacturer	10s. 3d.	9s.	8s. 6d.	
3. A silk merchant	9s.	8s. 3d. 8s. 6d.	7s. 6d.	
4. A Macclesfield expert	11s.	10s.—11s.	10s.	
<i>Tenderers—</i>				
1. Messrs. Worthington & Co.	—	—	10s.	The firm paying all dock charges.
2. Messrs. Milner & Co.	12s. 6d.	—	—	
3. Messrs. Henckell, Du Boisson & Co.	12s. 9d.	10s. 9d.	10s. 9d.	

It will be seen that Messrs. Henckell, Du Boisson & Co. not only made the highest tender for the whole consignment, but that they offered also to defray all the dock charges, which really raised their tender to 13s., 11s. and 11s. for the three qualities, respectively. There can be no doubt, therefore, of the soundness, in every respect, of the acceptance of their tender.

From annexed statement of the sale account (Appendix C), it will be seen that the total sum realised for the silk was 1,244l. for 2,143 lb

Conf. pp. 7,
8.

* Equal to Rs 9-15-1
per lb at an exchange
of 1s. 2d. per rupee.

the average price on the stock being about 11s. 7½d.* per lb. It will be noticed from the statement that the deduction for damaged silk as determined by "the dock examination and weightment," amounted to 8lb (see Appendix); that 2lb were used up as samples; and that Mr. Wardle received 16lb of No. 1, 21½lb of No. 2, and 12lb of No. 3, or 49½lb altogether, on condition that he prepared therewith effective samples of woven silks for the approaching exhibitions of silks and cabinet furniture at the Bethnal Green Museum (under the direction of the Lords of the Committee of Council on Education) and of Indian products at

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Sale of raw Silk

KASHMIR
SILK.Sir George
Birdwood's
memoran-
dum.Conf. p. 10,
et. seq.Conf. pp. 26,
27.

Earl's Court. It was decided between Mr. Lawrence and me to make no charge for these 49½ lb, as we considered that the Kashmir State would be best repaid by the excellent advertisement which the Bethnal Green and Earl's Court exhibitions would give the silk.

Mr. Wardle had to pay a sum of 2l. 2s. for one of his expert examinations and valuations of five samples of the silk ; and this sum should be deducted from the total purchase money, viz., 1,244l. leaving 1,241l. 18s. to be remitted by the Accountant General to the Government of India, for transmission to the Kashmir Darbar.

In addition to Mr. Wardle's valuable and detailed report of the 14th October 1895, a copy of which was sent to India last December, and a duplicate of which is hereto attached (Appendix E), three other brief reports on the silk have been received (Appendix F), namely, from Mr. Whittles, of Leek, and two separate anonymous clients of Messrs. Henckell, Du Boisson & Co. These four reports all speak most hopefully of the prospects of the raw mulberry silk of Kashmir in the markets of Europe, and call for the earnest attention of the Darbar.

I may add that I was constantly in personal discussion with all sorts of persons interested in this experimental consignment, and that so far as I can judge, there seems to me to be a unanimous opinion among English silk brokers, merchants, and silk manufacturers, throwers, dyers, and weavers, of the excellent quality of Kashmir raw mulberry silk, and of the high prices sure to be paid for it if carefully reeled, and imported, under its various denominations, of uniform quality. No doubt seems to be entertained of its competing successfully with the best Italian denominations of raw mulberry silk.

The 13th April 1896.

GEORGE BIRDWOOD.

From Sir J. A. Godley, Under-Secretary of State for India, to Thomas Wardle, Esq., dated 7th May 1896.

In continuation of my letter of the 4th of December last, and in acknowledgment of the receipt of Messrs. Clowes's bill for 2l. 2s., I am directed by the Secretary of State for India in Council to thank you for the valuable advice and assistance given by you in connection with the sale of the consignment of Kashmir raw mulberry silk recently received from the Darbar of that Native Indian State ; and to

S. 1822.

for the Kashmir Darbar.

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Mulberry.

KASHMIR
SILK.

inform you that the Accountant General at this Office has been instructed to forward to you a draft for 2l. 2s. in discharge of Messrs. Clowes's account with you.

APPENDICES.

Appendices.

APPENDIX A.

From R. Mukerji, Esq., Director of Sericulture, Kashmir, to Sir George Birdwood, K.C.I.E., No. 55 S., dated 29th November 1895.

I have the honour to state that, under order of the Jammu and Kashmir State Council, I have forwarded to your address, through Messrs. King, King & Co., of Bombay, 16 tin-lined boxes of silk thread for sale.

The enclosed list gives all the necessary information about the silk in the boxes.

ENCLOSURE IN ABOVE.

Quality and Quantity of Raw Silk consigned to Sir George Birdwood, K.C.I.E., the India Office, Whitehall, London, S. W., through Messrs. King, King & Co., Bombay.

Invoice of
raw silk.

Quality.	No. of boxes.	QUANTITY.					Insured value.	REMARKS.
		No. of skeins.	Weight.					
			Maund. Seer. Chittack. Tolas.				R a. p.	
No. 1	1	2,127	2	27	14	2½	2,697 9 3	At Rs25 per seer.
"	2	1,611	2	1	15	3½	2,049 7 3	
"	3	1,720	2	7	8	0½	2,187 11 9	
"	7	1,000	1	13	14	0½	1,347 0 6	
"	8	1,549	2	2	4	1	2,056 9 0	
"	9	1,000	1	12	12	1½	1,319 3 6	
"	10	800	1	0	14	3½	1,022 15 6	
"	11	1,003	1	10	0	2½	1,250 12 6	
"	12	1,368	2	27	2	4	1,679 6 0	
Total	Nine	12,177	15	24	6	4½	15,610 11 3	
Carried over	

S. 1822.

SILK :
Mulberry.

Sale of raw Silk

KASHMIR
SILK.
Invoice of
raw silk.

Quality and quantity of Raw Silk consigned to Sir George Birdwood, K.C.I.E., the India Office, Whitehall, London, S. W., through Messrs. King, King & Co., Bombay—continued.

Quality.	No. of boxes.	QUANTITY.				Insured value.	REMARKS.	
		No. of skeins.	Weight.					
			Maund. Seer. Chittack. Tolas.			R a. p.		
Brought forward	...	...	...	...	...	.....
No. 2 . . .	4	2,029	2	24	11	1½	2,512 13 9	At R24 per seer.
„ . . .	15	1,300	1	30	8	1	1,692 4 9	
„ . . .	16	1,005	1	13	15	1	1,294 12 9	
Total .	Three	4,334	5	29	2	3½	5,499 15 3	
No. 3 . . .	5	1,139	1	20	11	4½	1,214 14 0	At R20 per seer.
„ . . .	6	1,000	1	12	1	3½	1,042 2 0	
„ . . .	13	1,306	1	29	4	1½	1,385 6 0	
„ . . .	14	519	...	27	11	2	554 4 0	
Total .	Four	3,964	5	9	13	1½	4,196 10 0	
GRAND TOTAL.	Sixteen	20,475	26	23	6	4	25,307 4 6	

Mr. Lawrence's
minute.

APPENDIX B.

By the kind invitation of Sir George Birdwood I attended at the India Office to-day. The question of the prices offered for the Kashmir silk was discussed in the presence of Sir Charles Bernard, Sir George Birdwood, Mr. Rose, and myself.

The prices offered by Messrs. Henckell, Du Boisson & Co. are higher than those offered by Messrs. Milner & Sons. By Sir George Birdwood's calculation,—

	Quality.		
	1	2	3
Messrs. Henckell, Du Boisson & Co. offer for .	13	11	11
Messrs. Milner & Sons	12-3	...	9-9

for the Kashmir Darbar.

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KASHMIR
SILK.

Mr. Lawrence's
minute.

From the price point of view it is to the advantage of the Kashmir State to accept the offer of Messrs. Henckell, Du Boisson & Co.

The only doubt which arises is whether it would be in the interests of the future of Kashmir silk to sell direct to manufacturers like Messrs. Milner & Co. The object of the Kashmir State is to advertise the fact that good silk can be produced in Kashmir. I think that *merchants* like Henckell, Du Boisson & Co., are just as likely to push and advertise the Kashmir silk as manufacturers such as Milner & Co. I also raised the question whether Henckell and Du Boisson, in the interests of their Bengal silk business, were trying to get the Kashmir silk into their hands in order (a) to extinguish a rival industry, (b) to force it into the trade channel of Calcutta. Sir George Birdwood who knows the firm well reassures me on these points, and he feels sure that Henckell & Co. are *bonâ fide* purchasers who hope to make a handsome profit out of their purchase, and who will, in the ordinary way of business, make Kashmir silk known to the trade.

I therefore representing Kashmir as *amicus curiæ*, think it would be wise to accept the offer of Messrs. Henckell, Du Boisson & Co.

WALTER R. LAWRENCE.

The 24th February 1896.

APPENDIX C.

Statement of Sale Account, 16 Bales Kashmir Silk.

Sale account.

9	Bales, No. 1 quality, net weight 1,258lb :—							
		lb oz.			£	s. d.	£	s. d.
	Messrs. Henckell & Co.	1,234 6	at 12s. 9d.		786	18 3		
	Messrs. Milner & Co.	5 0	at 12s. 6d.		3	2 6		
	Mr. Wardle	16 0						
	Deduct damaged	2 0						
	„ samples	0 10						
	TOTAL	1,258 0					790	0 9
3	Bales, No. 2 quality, net weight 464lb :—							
		lb oz.			£	s. d.	£	s. d.
	Messrs. Henckell & Co.	440 0	at 10s. 9d.		236	10 0		
	Mr. Wardle	21 8						
	Deduct damaged	2 0						
	“ samples	0 8						
	TOTAL	464 0					236	10 0
	Carried forward				...		1,026	10 9

S. 1822.

SILK :
Mulberry.

Sale of raw Silk

KASHMIR
SILK.

APPENDIX C.

Sale account.

Statement of Sale Account, 16 Bales Kashmir Silk—contd.

		Brought forward			£	s.	d.	£	s.	d.
4	Bales, No. 3 quality, net weight 421 lb :—				...				1,026	10 9
		lb	oz.							
	Messrs. Henckell & Co.	394	0	at 10s. 9d.	212	18	0			
	Messrs. Whittles & Co.	5	0	at 10s.	2	10	0			
	Messrs. Worthington & Co.	5	0	at 8s. 3d.	2	1	3			
	Mr. Wardle	12	0							
	Deduct damaged	4	0							
	„ samples	1	0							
	TOTAL	421	0					217	9	3
								1,244	0	0

APPENDIX D.

From Messrs. Henckell, Du Boisson & Co., to Sir G. C. M. Birdwood, K.C.I.E., etc.,
dated 4th March 1896.

We thank you for your favours of the 29th ultimo. We enclose
herewith dock weight account, showing net weight . 2,063 lb—

	lb	oz.	
Sorting account showing	29	12	stained.
„ „ „	9	0	damaged and cut.
In all	38	12	unsound.
On which the allowance is assessed at			8 lb
Net weight to be paid for			2,055 lb

The damage has been assessed in the customary way, that is, no allowance is made in the price, but a deduction is made from the weight.

We annex account of the silk, including the samples received from you, showing total value, 1,236*l.* 6*s.* 3*d.*, against which we have already paid you 850*l.* and we now enclose cheque for 386*l.* 6*s.* 3*d.* in settlement of the balance.

Further testings give the range of No. 1 quality as 11 to 17 deniers, No. 2, 14 to 20 deniers, and No. 3, 18 to 37 deniers. Evidently much more supervision of the reeling is required.

S. 1822.

for the Kashmir Darbar.

SILK :
Mulberry.

ENCLOSURE I IN ABOVE.

KASHMIR
SILK.

Account of 16 Cases Kashmir Silk.

	lb	lb		£	s.	d.	Sale account.
9 Bales, No. 1 quality, net weight							
Deduct for damage	1,235	2					
		1,233	at 12s. 9d. per lb	786	0	9	
3 Bales, No. 2 quality, net weight							
Deduct for damage	441	2					
		439	at 10s. 9d. per lb	235	19	3	
4 Bales, No. 3 quality, net weight							
Deduct for damage	387	4					
		383	at 10s. 9d. per lb	205	17	3	
Add samples—							
4th February, No. 1. 1lb 6 ozs. at 12s. 9d.				0	17	6	
" " Nos. 2/3, 2lb at 10s. 9d.				1	1	6	
12th February, No. 3, 10lb at 13s.				6	10	0	
				£1,236	6	3	

ENCLOSURE 2 IN ABOVE.

Messrs. Henckell, Du Boisson & Co.

London and India Docks Joint Committee.

Copy of Damage Account, 2nd March 1896.

16 Bales Kashmir Raw Silk, Land Carriage, February 1896.

No.	lb	ozs.		No.	lb	ozs.	
1 {	1	12	Stained.	4 {	3	4	Stained.
	1	8	Cuts.		3	0	Damaged.
2	2	0	Stained.		0	8	Cuts.
3	...		Sound.	15	...		Sound.
7	...		Do.	16	1	4	Stained.
8	...		Do.	5	7	8	Do.
9	...		Do.	6 {	6	4	Do.
10	...		Do.		2	12	Damaged.
11	...		Do.	13 {	6	0	Stained.
12	...		Do.		1	4	Cuts.
				14	2	0	Stained.

J. ROMBELLS, Foreman.

J. BUDD, Warehouse Keeper.

SILK :
Mulberry.

Sale of raw Silk

KASHMIR
SILK.
Re-weight
account.

ENCLOSURE 3 IN ABOVE.
London and India Docks Joint Committee.
Re-weight Account, 29th February 1896.
16 Bales Kashmir Silk, Henckell, Du Boisson & Co., 29th February
1896, Land Carriage, 27th February 1896.

No.	Weight.			Tare, etc.		Net lb
	Cwt.	qrs.	lb	2 oz.	draft.	
1	1	3	4	8	5	195
2	1	2	2	12	...	165
3	1	2	14	12	...	177
7	1	0	1	8	...	108
8	1	2	3	12	...	166
9	0	3	27	8	...	106
10	0	3	2	0	3	83
11	0	3	21	8	5	100
12	1	1	0	12	...	135
4	1	3	22	4	...	213
15	1	1	7	12	...	142
16	0	3	5	4	3	86
5	0	3	16	4	...	97
6	0	3	26	3	5	105
13	1	1	5	4	...	140
14	0	1	20	12	3	45

R. SWEENEY.
J. BUDD.

APPENDIX E.

Mr. [now Sir
Thomas]
Wardle's
report.

Report on Kashmir Raw Silk by Mr. Thomas Wardle, F.C.S., President of the Silk Association of Great Britain and Ireland—dated Leek, Staffordshire, the 14th October 1895.

I have carefully examined the samples of Kashmir silk on which you requested me to report in your letter of the 11th July. I have conducted the inquiry on the basis of my examinations of the various colonial silks on which I was requested to report in 1886 by the Royal Commission of the Colonial and Indian Exhibition. A reference to that report will be found useful for the purpose of comparison.

I have consulted several experts on whose judgment I can rely as to the commercial value of the samples from two points of view ; one, that of merchants and silk brokers, the other of manufacturers. In addition, I give my own estimate of the value.

The merchants and silk brokers who supply the manufacturer of course require their profit, and naturally estimate the value at less than the manufacturer, who has to pay that profit. On this point, with particular reference to the problem of the successful development of sericulture in Kashmir, I will say a few words further on.

for the Kashmir Darbar.

SILK :
Mulberry.

Cocoons.

KASHMIR
SILK.

Mr. [now Sir
Thomas]
Wardle's re-
port.

I have not had the advantage of examining the cocoons from which these samples of silk were obtained, but, judging from the latter, I am of opinion that the silk is not that of the *desi* (i. e., "country" *Bombyx fortunatus*) or the Madrasi worm (*Bombyx cræsi*) of Bengal, but probably of the mulberry worm (*Bombyx Mori*) of Europe, a univoltine species, presumably from one or more of the cultivated races of Italy, or France, or both; and as it is the species which yields the silk of commerce of France, Italy, China, and Japan, it is, I think, admirably suited to Kashmir, and on the whole superior to the abovementioned multivoltine species of Bengal.

As no cocoons have been sent with the samples of raw silk and waste I have received for examination, I have not been able to give the particulars of the first six denominations in the following table, which is based on that I devised for my aforesaid Report on Silks at the Colonial and Indian Exhibition.

Samples examined.

The nine examples of Kashmir silk received are of the following states and qualities.

Two samples, Nos. 1 and 2, of silk waste accompany the seven hanks of raw silk. One is made up as the ordinary *chassum* of Bengal, the other as ordinary silk waste.

The seven samples of raw silk (Nos. 3 to 9) consist of—

- One skein of 1st quality white gum.
- „ „ „ „ yellow gum.
- „ „ 2nd „ „
- „ „ 3rd „ „
- „ „ 4th „ „
- „ skein from very poor cocoons.
- „ „ double cocoons.

The reelable thread of the cocoon is composed of two cylindrical fibres, each termed in France "brin." They are simultaneously seriposited by the silkworm from orifices on each side of its head, and are termed in France "bave." They consist of a homogeneous substance termed fibroin; they are surrounded and cemented together by a substance resembling gelatine or gum, named in chemistry "sericin" or

S. 1822.

SILK: Mulberry.	Sale of raw Silk
KASHMIR SILK. Report of Lyons condi- tioning house.	<p>silk gelatine, technically termed in England "gum," and in France <i>grés</i>. This gum constitutes about 25 to 33 per cent. of the total weight, and is easily dissolved and removed by boiling in soap solution, previous to the silk being dyed.</p> <p>The statement on pages 13 and 14 gives all the leading particulars of my examination of the above nine examples in a tabular form.</p> <p style="text-align: center;"><i>Report of the Lyons Conditioning House.</i></p> <p>I sent the samples to the Lyons Conditioning House, with a request that they would be so good as to give the Government of India an opinion on the silk, both as to its value and to its properties.</p> <p>I enclose the conditioning notes, which show results which may be taken as closely approximate to my own conclusions. They have not reported on the values of the samples. However, the values I send may be regarded as accurate, as I have taken great pains to check them. Since I valued them the prices stated in my table may be safely placed about 5 to 10 per cent. higher, owing to a recent rise in the raw silk markets in England and France which, owing to a greatly increased demand, will probably be maintained for some time yet.</p>

TABULAR STATEMENT.

Species Bombyx Mori, probably Univoltine.

for the Kashmir Darbar.										
No.	Description,	First quality Yellow.	First quality White.	Second quality.	Third quality.	Fourth quality.	From very poor Cocoons.	From Doppio Cocoons.	Frison.	Chassum. No.
1	Weight of cocoon . . .	No cocoons sent.	...	...	...	...	...	...	...	...
2	Dimensions of cocoon . . .									
3	Weight of bave reeled from cocoon.									
4	Length of bave reeled from cocoon.									
5	Mean percentage of silk reeled from cocoon.									
6	Mean percentage of waste or frison in the cocoon.	4	4	4	7	9	Very variable.	Most variable.	...	...
7	Number of baves composing the raw silk thread, i.e., the number of cocoons used to produce the thread.									
8	Size in deniers in hank of 520 yards.									
9	Mean diameter of brin or cocoon single fibre.	10 to 12 deniers. $\frac{1}{1200}$ inch	10 to 12 deniers. $\frac{1}{1200}$ inch	10 to 15 deniers. $\frac{1}{1000}$	17 to 18 deniers. $\frac{1}{1100}$	28 deniers $\frac{1}{3200}$	...	...	...	...
10	Mean diameter of bave or cocoon double fibre.	$\frac{1}{1700}$ inch	$\frac{1}{1100}$	$\frac{1}{1000}$	$\frac{1}{1100}$	$\frac{1}{1100}$	$\frac{1}{1100}$	$\frac{1}{1100}$	...	...

SILK:
Mulberry.KASHMIR
SILK.
Report of
Lyons condi-
tioning house.

S. 1822.

SILK :
Mulberry.

KASHMIR
SILK.
Report of
Lyons condi-
tioning house.

Sale of raw Silk

TABULAR STATEMENT.
Species Bombyx Mori, probably Univoltine—continued.

No.	Description.	First quality Yellow.	First quality White.	Second quality.	Third quality.	Fourth quality.	From very poor Cocoons.	From Doppio Cocoons.	Frison.	Chassum. No.
11	Mean tenacity or strength of the thread of raw silk.	24 drams	20·8 drams	32 drams	38·5 drams	44 drams	...	...	...	11
12	Mean elasticity or tension of the thread of raw silk.	4 inches	3·9 inches	5·1 inches	5·5 inches	5·2 inches	8·2 inches	...	...	12
13	Mean tenacity or strength of the brin.	3 drams	3 drams	3 drams	2½ drams	2½ drams	...	...	...	13
14	Mean elasticity or tension of the brin.	4 inches	3·9 inches	5·1 inches	5·5 inches	5·2 inches	...	...	...	14
15	Net weight of silk per lb. after removal of its gum.	12 oz. 7 drams.	12 oz. 12 drams.	12 oz. 5 drams.	11 oz. 14 drams.	11 oz. 11 drams.	...	...	...	15
16	Colour of raw silk in gum	Yellow	White	Yellow	Yellow	Yellow	Yellow	Yellow	...	16
17	Merchant's and broker's valua- tion per lb.	9s.	9s.	8s. 3d. to 8s. 6d.	7s. 9d.	7s. 9d.	6s. 6d.	2s.	1s. 3d. to 1s. 4d.	17
18	A Leek manufacturer's skilled expert's valuation per lb.	10s. 3d.	10s. 3d.	9s.	8s. 6d.	8s.	6d.	3s.	...	18
19	My valuation	10s. 6d.	11s. 6d.	10s.	8s. 9d.	8s. 6d. to 9s.	7s. 6d. to 8s.	3s. 6d.	1s. 8d.	19
20	A skilled Macclesfield expert's valuation per lb.	11s.	12s.	10s. to 11s.	10s.	8s. to 9s.	7s. 6d. to 8s.	2s.	1s. 6d.	20
21	Lyons conditioning house, size in deniers of 520 yards, compare with No. 8.	12½ deniers	11½ deniers	15 deniers	19½ deniers	28 deniers	39½ deniers	113 deniers	...	21

U. 1822.

**SILK :
Mulberry.**

Sale of raw Silk

**KASHMIR
SILK.**

Report of
Lyons condi-
tioning house.

Décret du 25 Juin 1856.

Condition Publique des Soies, Laines et Cotons.

Bureau de Titrage.

N° d'ordre, 1606.

Lyon, le 26 Septembre 1895.

Echantillon, 1st quality, skein white.

Déposé par M, Association Anglaise.

Observations.						TITRE.	
						en grammes et centig.	en deniers.
						0'60	11'29
						0'60	11'29
						0'60	11'29
						0'60	11'29
						0'60	11'29
						0'60	11'29
						0'60	11'29
						0'65	12'24
						0'65	12'24
						0'65	12'24
Elasticité.	Ténacité.	Tors.	Filage.		0'65	12'24	
					0'65	12'24	
					0'65	12'24	
					0'65	12'24	
					0'70	13'18	
					0'70	13'18	
					0'70	13'18	
20%	30 ^{mes}				0'70	13'18	
20	35						
21	40						
21	45						
22	50						
						10'25	192'95
Titre ordinaire sur 500 mètres						0'64	12'05
Poids conditionné						10'26	
Titre conditionné sur 500 mètres						0'641	12'07
Ancien titre sur 476 ^m {						ordinaire	11'47
						conditionné	11'49
Droit de titrage, Fcs 2.							

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for the Kashmir Darbar.

SILK :
Mulberry

Décret du 25 Juin 1856.

Condition Publique des Soies, Laines et Cotons.

Bureau de Titrage.

KASHMIR
SILK.
Report of
Lyons condi-
tioning house.

N° d'ordre, 1608.

Lyon, le 26 Septembre 1895.

Echantillon, 2nd quality, skein yellow.

Déposé par M, Association Anglaise.

Observations.					TITRE.	
					en grammes et centig.	en deniers.
					0'75	14'12
					0'75	14'12
					0'80	15'06
					0'80	15'06
					0'80	15'06
					0'80	15'06
					0'85	16'00
					0'85	16'00
					0'85	16'00
					0'85	16'00
					0'90	16'94
					0'90	16'94
					0'90	16'94
					0'90	16'94
					0'90	16'94
					12'60	237'18
Titre ordinaire sur 500 mètres					0'84	15'81
Poids conditionné					12'65	
Titre conditionné sur 500 mètres					0'843	15'87
Ancien titre sur 476 ^m { ordinaire						15'05
{ conditionné						15'10
Droit de titrage, Fcs, 2.						

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SILK :
Mulberry.

Sale of raw Silk

KASHMIR
SILK.

Report of
Lyons condi-
tioning house.

Décret du 25 Juin 1856.
Condition Publique des Soies, Laines et Cotons.
Bureau de Titrage.

N° d'ordre, 1609. Lyon, le 26 Septembre 1895.
Echantillon, 3rd quality, skein yellow.
Déposé par M, Association Anglaise.

Observations.					TITRE.						
					en grammes et centig.	en deniers.					
					1'00	18'83					
					1'00	18'83					
					1'05	19'77					
					1'05	19'77					
					1'05	19'77					
					1'05	19'77					
					1'05	19'77					
					1'05	19'77					
Elasticité.	Ténacité.	Tors.	Filage.		1'10	20'71					
					1'10	20'71					
					1'10	20'71					
					1'10	20'71					
					1'10	20'71					
					1'15	21'65					
					1'15	21'65					
					16'10	303'13					
Titre ordinaire sur 500 mètres					1'073	20'20					
Poids conditionné					16'20						
Titre conditionné sur 500 mètres					1'08	20'33					
Ancien titre sur 476 ^m {					ordinaire		19'23				
					conditionné		19'35				
Droit de titrage, F ^{cs} 2.											

S. 1822.

SILK :
Mulberry.

Sale of raw Silk

KASHMIR
SILK.
Report of
Lyons condition-
ing house.

Décret du 25 Juin 1856.
Condition Publique des Soies, Laines et Cotons.
Bureau de Titrage.

N° d'ordre, 1612. Lyon, le 26 Septembre 1895.
Echantillon, Silk, very poor cocoons.
Déposé par M, Association Anglaise.

Observations.					TITRE.	
					en grammes et centig.	en deniers.
					1'30	24'48
					1'70	32'01
					1'75	32'95
					1'75	32'95
					1'80	33'89
					1'80	33'89
					1'85	34'83
					1'95	36'72
					2'00	37'66
					2'00	37'66
	Elasticité.	Ténacité.	Tors.	Filage.		
	19%	100Gmes			2'05	38'60
	20	105			2'10	39'54
	20	110			2'35	44'25
	21	115			2'45	46'13
	22	120			2'95	55'55
					3'75	70'62
					3'85	72'50
					37'40	704'23
Titre ordinaire sur 500 mètres					2'20	41'42
Poids conditionné					37'51	
Titre conditionné sur 500 mètres					2'206	41'54
Ancien titre sur 476m { ordinaire						39'43
{ conditionné						39'54
Droit de titrage, F 2.						

S. 1822.

SILK :
Mulberry.

Sale of raw Silk

KASHMIR
SILK.
Mr. [now Sir
Thomas]
Wardle's
report.

Remarks.

The result of this examination convinces me that the silk of Kashmir is of as high a quality physically as any silk from any other part of the world, and that an important future is in store for Kashmir in a greatly extended sericultural output. Judging from these examples I am more than satisfied with the absolute suitability of Kashmir, in a climatic sense, for the production of silk of superior strength, roundness of fibre, and freedom from structural defects.

Improved Reeling.

If I may venture to mention a few necessary conditions and precautions, I would like to say that greater attention must be paid to the reeling of the cocoons. The samples point to the necessity for an improvement in the regularity of size in the structural condition of the multiple thread of raw silk by better reeling. This can easily be done by selecting the best form of tavelette, and more highly skilled cocoon sorters and reelers. The number of baves in each thread is too variable, the finer baves being at times reeled together instead of being reeled with coarser baves.

Healthy Surroundings.

The commercial value of the silk would be greatly enhanced by healthier conditions of production. Greater cleanness, greater size greater regularity of fibre, and greater freedom from duvet would thereby be attained, and these must be recognised as first requirements of success. Healthy surroundings, and good ventilation in the breeding magnaneries are the predetermining conditions of such success, and therefore of imperative importance.

The quality, although respectively good in the various grades, is not equal to filature Cantons, filature Japans, or Italians.

Attention to all these points would soon render it unnecessary for Europe to depend so largely upon supplies from the further East.

Capital and Security of Contract.

I may be travelling outside my instructions, but I am constrained to add that, as British capital will be required to fully develop the silk-producing resources of Kashmir, two things are, in my opinion, necessary.

S. 1822.

for the Kashmir Darbar.

SILK:
Mulberry.

KASHMIR
SILK.

Mr. [now Sir
Thomas]
Wardle's
report.

First, that there should be absolute security of contract in Kashmir, and, second, that the Government should, in order to encourage the application of such capital, join in any attempt to produce silk on a large scale, providing some capital, and participating in the profit or in some equivalent way.

Shipment direct.

I also feel sure that, if the silk could be shipped direct to London and there placed on the market through the brokers, avoiding Bombay and Calcutta altogether, the chances of profit would be materially enhanced. This more simple mode of transfer would greatly simplify matters, and would place the reeler much nearer to the consumer, and would reduce the number of profits before the silk gets into the consumer's hands, as is now unfortunately the case with our imports from Bengal, China, and Japan.

My visit to Bengal.

It may be remembered that in 1886, at the instance of Mr. (now Sir) Edward C. Buck, I visited India, and reported on Bengal sericulture. I enclose a copy of my report. The two principal causes which had led to a decline of sericulture there were bad reeling and an excessive mortality of the silkworms. I found that not less than 60 per cent. of the silkworms died of disease. I recommended the Government of India to send some competent person to France and Italy, and there to study at the Government sericultural laboratories of Montpellier and Padua all that related to the growth of the mulberry and the proper rearing of the silkworms. Sir E. C. Buck selected a young native, Mr. Nitya Gopal Mukerji, and sent him out as I had suggested. He was away about two years, and completed his studies by several months' most advantageous study in Monsieur Pasteur's laboratory in Paris of silkworm diseases and their prevention.

When Colonel Parry Nisbit was appointed to Kashmir he very kindly obtained for me a good deal of information about sericulture there, and I suggested that Mr. Mukerji, who had been installed in a sericultural laboratory at Berhampur, should be sent over to Kashmir and instal a laboratory there.

S. 1822.

SILK :
Mulberry.

Sale of raw Silk

KASHMIR
SILK.

Mr. [now Sir
Thomas]
Wardle's
report.

Conf. below.

Report of
Messrs. War-
ner and Sons.

Figured Brocades from Kashmir Silk.

This has, I believe, been done, because afterwards I received a letter from Mr. R. Mukerji, Director of Sericulture of Srinagar, Kashmir, informing me that he was sending some Kashmir silk for the Exhibition at Stafford House, London, in May 1894. I had the silk thrown, dyed, and woven for that Exhibition. The manufactured silk was a kind of furniture brocade, and attracted considerable attention. I had the honour of showing it to the Queen, who was very much interested with it. It was also seen by the Prince of Wales and most of the other members of the Royal family. The silk was woven by Messrs. Warner and Sons of Spitalfields and Braintree, who reported on it in a letter of which I enclose a copy See Appendix I.

I also send herewith for inspection the piece of this figured brocade, all of which, or, at least, half of it, I should like to have returned when done with, as it is the first specimen of Kashmir silk dyed and woven in England.

Messrs. Warner informed me they would be glad to take all the silk that could be sent from Kashmir for some time if their suggestions were carried out.

I thought it well to add the above to my report, which, if considered superfluous, will be taken as showing the intense interest I have taken for several years past in the founding of a sericultural industry in Kashmir for the European markets.

From Messrs. Warner and Sons, 8, Newgate Street, London, to Thomas Wardle, Esq.,—dated the 12th May 1894.

APPENDIX I.

We are glad to inform you that the Kashmir silk which we wove into a small piece of goods at our factory in Spitalfields seems to us to be the best we have ever seen from India; it is very strong, and very bright when dyed.

The sample was coarse in size, which might arise from having too many cocoons used in the reeling; but, if it could be obtained finer in size, its market price would be about equal to that of China silk, and it could then be brought in general use. Otherwise it would only be useful in certain fabrics, such as tapestry.

It gives us much pleasure to be able to report so favourably on a product of our Indian Empire.

S. 1822.

for the Kashmir Darbar.

SILK:
Mulberry.

APPENDIX II.

From Walter R. Lawrence, Esq., 22, Sloane Gardens, London, S. W., dated the 7th November 1894.

KASHMIR
SILK.
Remarks by
Mr. Law-
rence.

I have the honour to acknowledge the receipt of your letter No. 1612, R. S., of yesterday. Mr. Wardle is correct in supposing that the silk is that of the **Bombyx Mori** of Europe, a univoltine species, and his general remarks are, for the most part, applicable to the condition of sericulture in Kashmir.

Practically, Kashmir is at present only working at one twenty-fourth of its full power. The valley is crowded with mulberry trees, but, owing to the difficulty of supervision, and to doubts as to the expediency of spending money on a scheme controlled by an amateur like myself, I have insisted on confining our efforts to a scheme which was self-supporting. Hence we did not attempt to introduce apparatus for improved reeling, nor have we spent money on "magnaneries." An Italian expert, Signor M. Bassi, now employed in wine making, accompanied me on inspections, and was of opinion that the erection of magnaneries was not necessary, and held that the ordinary Kashmir cottage, easily ventilated and easily warmed, was admirably suited to the rearing of silk worms.

If, however, improved reeling appliances and special magnaneries are introduced, they should only be introduced by European capital, and under the supervision of European experts. The Kashmir State could never control operations on the scale which they will quickly attain if capital were forthcoming. The important factor in the future of sericulture in Kashmir is the presence of a large number of Kashmiris known as *kirm-kash* or "worm destroyers," who thoroughly understand the business of rearing silkworms and who only required skilled supervision. The local agency is present, all that is required is capital and European experts.

The next point in Mr. Wardle's remarks refers to "capital and security of contract." Security of contract is no doubt necessary, but I would urge that the Government should not join in the business. I would suggest that the Kashmir State should be asked to lease the right of collecting mulberry leaves, and to lease sufficient ground for the purpose of erecting filatures, and if need be, of magnaneries. The one objection which the Darbar has against European capital being introduced is that the capitalist would find fault with the legal institutions of the country and would seek the jurisdiction of the

S. 1822.

SILK: Mulberry.	Sale of raw Silk
KASHMIR SILK. Remarks by Mr. Law- rence.	<p>Resident. If it were clearly stated that in all suits arising out of the business of sericulture the lessee would be subject to the jurisdiction of the Kashmir Courts, I believe that His Highness the Maharaja would consent.</p> <p>I am strongly in favour of direct shipment. The Kashmir State will feel secure of fair treatment if its silk is sold under the "ægis" of the India Office, official or unofficial. It is somewhat nervous on this point, as an experiment in selling shawls in Paris some years ago was a signal failure. Another reason, perhaps fanciful, is that efforts have been made from time to time to bring Kashmir silk under the control of French houses.</p> <p>I need not dwell on the importance of making some use of Kashmir's wealth of mulberry trees, nor on the advantages which would accrue to the labouring classes, to the peasants who regard sericulture as a cottage industry, and to the State. I should add that at present there are four Europeans carrying on business in Kashmir without hindrance and without friction.</p> <p>APPENDIX F (1).</p> <p>From Thomas Whittle, Esq., H. E. W., Leek, Staffordshire, to Sir George Birdwood, K.C.I. E.,—dated the 11th March 1896.</p> <p>Enclosed I beg to hand you cheque value 2l. 10s. in payment of the 5th sample of raw silk sent to me by Mr. Thomas Wardle of this town. <i>It was the third quality I had, and I consider it very satisfactory. If reeled up to 30 and 40 deniers it would suit the Leek trade. The better qualities would suit if reeled from 16 up to 24 deniers.</i></p> <p>APPENDIX F (2).</p> <p>Manufacturer's Reports on Samples, received from Messrs. Henckell, Du Boisson & Co., 11th February 1896.</p> <p>FIRST REPORT.</p> <p>"No. 1, yellow.—This we make nice bright silk with a good amount of bone or feel, a firm hard thread, but a little knibby.</p> <p>"No. 2.—Not so good a colour as No. 1 nor so bright, has similar feel, but is more lumpy and dirty.</p> <p>"No. 3.—Equal to No. 1 in cleanness, but like No. 2 in colour and lack of brightness.</p> <p>S. 1822.</p>

for the Kashmir Darbar.

SILK :
Mulberry.

" *White*.—The whiter skeins are as dirty as to 2 yellow, but soft, not firm or boney. The brown skein very similar, perhaps the cleaner of the two.

"We think the yellow samples partake much of the nature of Italian silk, but if the knibs and dirt had been kept out it would have been much improved. The white is softer and we think scarcely equal in value. We should like, however, to test 20 or 30lb before expressing a very definite opinion as to the value."

The firm that sent the above report asked us the price of the silk, and we answered "probably 14s. for No. 1, 13s. 6d. for No. 2, and 13s. for No. 3," and in reply they write as follows:—

"The prices you name seem to us *outside value*. We are very full of silk and don't care to try all three qualities, but if you will send us 10lb of No. 3 we will test it."

SECOND REPORT.

" *1st*.—The silk should be banded with either boiled silk or spun and the bands are too tight.

" *2nd*.—Generally it is not regular, *i.e.*, there are fine places in it, for instance, the sample yellow No. 2 ranges from 12 to 20 deniers, and No. 3 ranges from 16 to 24 deniers.

" *3rd*.—The strength is found good. The silk winds fairly well. In places it is soft and fluffy.

"The silk is such as should find a market here. It has more nerve than Bengal, but it is not so regular in size as Sindahs for instance. By this information you will be able to get at its value."

Memorandum on the sale in London of the second consignment of raw silk received from the Kashmir Darbar in June 1897.

Sir George
Birdwood's
memoran-
dum.

In April last Captain J. L. Kaye, the Assistant Resident in Kashmir, wrote from Srinagar asking me to again assist the Darbar in selling in the London Market a consignment of raw silk of three qualities, five cases of the first quality, two of the second, and one of the third, weighing 832lb 8oz., and informing me that he had forwarded the cases to me through Messrs. King, King & Co., of Bombay. On the receipt of the consignment in June last, I decided to ask Messrs. Henckell, Du Boisson & Co. of Laurence

S. 1822.

**SILK:
Mulberry.**

Sale of raw Silk

**KASHMIR
SILK.**

Sir George
Birdwood's
memoran-
dum.

Pountney Lane, to make an offer for the whole of the silk, or, failing that, to state on what terms they would undertake to dispose of the consignment in the open market. I felt that this firm were in a position to obtain a far better price for the silk than it was possible for me to get through any other channel.

The firm were unable to make any offer for the silk themselves, but stated that they would be pleased to dispose of it on behalf of the Kashmir Darbar at the highest price obtainable, and would do their best to get buyers who were most likely to help in the future development of the Kashmir silk industry. In acknowledging the receipt of the consignment Messrs. Henckell, Du Boisson reported "that the whole of the silk is in good condition, except a very trifling quantity which has been damaged, part of it by nails having been driven through the wood and tin into the silk and cutting it, the remainder of the damage being a few skeins that "had been stained before they were packed."

The five bales of No. 1 quality silk were sold in July at 10s. 9d. per lb, and Messrs. Henckell, Du Boisson remark on this :—

"We consider this a very fair price for the silk. It is perhaps slightly better made than last year's consignment, but still it varies from 13 to 21 deniers in size, and though the nature of the thread is excellent, its great irregularity in size prevents its being used in the highest class of goods."

In September the two cases of the second quality silk were sold at 10s. per lb and in December the last case (third quality) was sold at 9s. per lb.

The average price realized for the whole consignment was 10s. 5d. against an average of 11s. 7d. last year. The higher price given for the previous consignment was, I am informed, due to the buyers having considered the silk better spun than it proved to be when worked up, and in consequence the buyers were to some extent losers.

From the annexed statement of account of Messrs. Henckell, Du Boisson & Co. it will be seen that the total net proceeds realised by the whole consignment of 832 lb 8oz. of silk was £422 6s. 9d.

I am still of opinion that there is every hope of the Kashmir silk finding a profitable market in Europe, the one essential being perfect reeling.

The 16th December 1897.

GEORGE BIRDWOOD.

S. 1822.

for the Kashmir Darbar.

SILK :
Mulberry.

Account sales and net proceeds of Kashmir silk sold by order of Sir
George Birdwood, K.C.I.E., for account and risk of the Kashmir
Darbar.

KASHMIR
SILK.
Account
sales.

No. I 1-5 . 5 Cases Kashmir silk
II 7-8 . 2 " " "
III 6 . 1 Case " "
8 Cases.

		£	s.	d.	£	s.	d.
July 22 1897 .	Sold by private sale prompt 22nd. October 1897 :— 5 bales weighing net 572lb @ 10s. 9d. per lb Cash received 6th August . Add—131 days' interest @ Bank of England rate due 15th December 1897	307	9	0			
					310	15	1
September 15. 1897 :—	Sold by private sale prompt 15th December 2 bales weighing net 176lb 12oz. @ 10s. per lb Cash received 15th Decem- ber 1897	88	7	6			
					88	7	6
November 18. 1897 :—	Sold by private sale prompt 29th November ½ bale weighing net 83lb. 8oz. at 9s. per lb 832-4 Cash received 29th December Add—16 days' interest @ Bank of England rate due 16th December 1897	37	11	6			
					37	12	9
					436	15	1

* 5lb inferior quality taken out of this lot
and included in No. III quality.

Charges.

July 1	Dock charges	4	12	8	
	Rent	0	16	4	
	Reeling	1	7	0	
	Interest on charges	0	2	4	
	Petty expenses and postages	0	5	0	
	Fibre insurance	0	15	0	
	Brokerage ½ per cent.	2	3	4	
	Commission 1 per cent.	4	6	8	
			14	8	4
	Value 15th December 1895	422	6	9	

E. E.

LONDON : } HENCKELL, DU BOISSON & CO.
The 15th December 1897. }

S. 1822.

G. I. C. P. O.—No. 1333 R, & A,—12-9-98,—2,225,—H, R.

(Vegetable Product Series, No. 42.)
(Fibres.)

THE
AGRICULTURAL LEDGER.

1898—No. 11.

ANANAS SATIVA.

(PINE APPLE.)

(*Dictionary of Economic Products, Vol. I., A. 1045-57.*)

PINE APPLE FIBRE.

Review of Correspondence showing results of a chemical examination in the Scientific Department of the Imperial Institute of a sample of the fibre prepared in Assam.

The Honourable Mr. Buckingham, C.I.E., of Amguri, Assam, forwarded to the Reporter on Economic Products a small sample of pine apple fibre for valuation by an expert. The sample was considered too small to send to the Imperial Institute. It was accordingly submitted to the Calcutta Chamber of Commerce with a request that, if possible, a note might be furnished as to quality and market value of the fibre. The Secretary to the Chamber replied, stating that on inquiry it had been ascertained there was no local market for such material, and that hence a valuation could not be given. The Secretary suggested, however, that a quotation for the fibre might possibly be forthcoming in London.

The attempt to obtain an Indian valuation having failed, the sample was transmitted to the Imperial Institute, London, for favour

INTRO-
DUCTORY.

A. 1045-57.

ANANAS
sativa.IMPERIAL
INSTITUTE.

Pine Apple

of expert's opinion. On its reaching Sir F. A. Abel he kindly wrote as follows :—

From Sir F. A. Abel, Bart., K.C.B., Honorary Secretary and General Director, Imperial Institute, to George Watt, Esq., M.B., C.M., C.I.E., Reporter on Economic Products to the Government of India, Indian Museum, Calcutta, —No. 186-3 (Flying Seal Series, No. 112), dated London, the 29th May 1897.

With reference to a sample of pine apple fibre from Assam, which has been handed to me by Mr. Royle, for submission to practical Experts, I have to state that enquiry has been made of one of our Referees as to whether a few pounds of the material can be supplied at once for textile purposes, as he believes he is enabled to have this done by a new process, which is giving good results with other fibres.

I thought it right to communicate this enquiry to you without loss of time.

This was replied to by R. E. P. No. 1415—67 F.S., dated the 6th July 1897, stating that a further sample had been asked for. R. E. P. No. 1636—67 F. S., dated the 4th August 1897, subsequently advised the despatch of a further quantity, 3lb, of the pine apple fibre in question. The following communication was received in due course from the Imperial Institute :—

From Sir F. A. Abel, Bart., K.C.B., Honorary Secretary and General Director, Imperial Institute, to George Watt, Esq., M.B., C.M., C.I.E., Reporter on Economic Products to the Government of India, Indian Museum, Calcutta, —No. 347-3 (Flying Seal Series, No. 121), dated London, the 4th November 1897.

Referring to your letters of the 6th July and the 4th August, sent in response to my application for a somewhat larger sample of pine apple fibre than that forwarded by you to Mr. Royle in January of this year, I have now the pleasure of communicating to you the results of chemical examination of the fibre, and the opinion furnished by our Expert Referee for fibres with regard to its quality and value.

The results furnished by examination of the specimen first received, by the comparative method followed in all instances in the Scientific Department, are as follows :—

The fibre contained 0·9 per cent. of mineral constituents or ash ; 11·33 per cent. of moisture in its normally dry condition ; and the percentage of cellulose was 80·87. Its loss in weight by submission to (A) Hydrolysis amounted to 14·21 per cent. and by (B) Hydrolysis

A. 1045-57.

Fibre.	ANANAS sativa.
<p>to 18·12 per cent. Treated by the mercerising process it lost 17·32 per cent. ; its acid purification entailed a loss of 1·52 per cent. ; and it gained 35·83 per cent. by nitration.</p>	<p>CHEMICAL EXAMINA- TION RESULTS.</p>
<p>The average length of the ultimate fibre was 2·6 min., but, on submission of the second sample received to practical tests, the yield of "line" or long spinning fibre was much higher in proportion than that obtained from medium European flax ; and the spinning qualities of the long, as well as of the shorter fibre, are reported to be good. The second sample received was too small to yield exact practical results, but, so far as can be judged by its behaviour, the fibre is very promising in character, and, when well prepared, yields material, more nearly resembling flax in character than hemp which would be very suitable for spinning into fine twine, and for textile purposes, if it be properly softened.</p>	<p>Compares favourably with European Flax.</p>
<p>It is considered that the results furnished by the sample under examination are sufficiently good to warrant the recommendation that a sample shipment of at least five tons be made to England for trial purposes. That quantity would suffice to yield exact practical results on a fair working scale, as to its application by spinners, etc., to various purposes. The fibre would have to be submitted to a preparing process which would not be costly, and would be available for use in India if it be considered desirable eventually to treat it on the spot, after its value had been thoroughly determined here.</p>	<p>Shipment in quantity suggested.</p>
<p>At the present time, the value of fairly clean fibre in the London market would probably be from £20 to £25 per ton. A specimen of the "line" or long thin fibre furnished by the sample operated upon, is forwarded herewith.</p>	<p>Valuation.</p>
<p>Regarding the question of supplying the fibre in considerable quantity, the R. E. P. replied as under :—</p>	
<p><i>From George Watt, Esq., M.B., C.M., C.I.E., Reporter on Economic Products to the Government of India, Indian Museum, to Sir F. A. Abel, Bart., K.C.B., Honorary Secretary and General Director, Imperial Institute, London, —No. 2851—67 F. S., dated Calcutta, the 22nd December 1897.</i></p>	
<p>I have the honour to acknowledge, with thanks, the receipt of your letter No. 347—3 (Flying Seal Series No. 121), dated the 4th November last, communicating the results of chemical examination of a sample of pine apple fibre and of the opinion furnished by the Expert Referee for fibres of the Imperial Institute with regard to its quality and value. The sample in question was furnished by the</p>	
<p>A. 1045-57.</p>	

ANANAS
sativa.QUESTION
of a
LARGER
SUPPLY.

Pine Apple

Honourable Mr. J. Buckingham, who obtained it from a small experimental cultivation of the plant at Amguri in Assam.

With reference to the proposal now made for the supply of five tons of the fibre, I have the pleasure to forward herewith an extract from my letter No. 2738—67, dated the 9th instant, to the address of Mr. Buckingham. My ability to comply with your request for so large a quantity will very greatly, if not entirely, depend on Mr. Buckingham's reply.

Extract from letter No. 2738—67, dated the 9th December 1897, to the Honourable Mr. J. Buckingham, Amguri, Assam.

In continuation of previous correspondence (ending with this office No. 1606—67, dated the 2nd August 1897), I have now the pleasure of forwarding to you copy of the report just to hand from the Imperial Institute on your sample of pine apple fibre furnished with yours of the 15th July last. I enclose a very small sample of the fibre as cleaned by the experts of the Institute. You will see that the report is of a most encouraging nature. I shall be glad to hear from you with regard to the proposal to furnish the Institute with five tons of the fibre. I fear that is beyond your present capability, and that, before you could do so, it would be necessary to lay out a fairly large experimental plot. From what I saw of the luxuriant growth of the pine apple in your garden and indeed all over Assam, I should think it highly probable that you may be instrumental in the establishment of a new industry to the province. I should like to have your views on the matter before any further action is taken. . . . If you contemplate starting the industry on a large scale and would rather that publicity was not, however, given to the results so far attained, I shall of course publish nothing for a time.

The following letter and its enclosure shows action taken so far in the matter of obtaining the larger supply of pine apple fibre as suggested by the Expert Referee at the Imperial Institute :—

From George Watt, Esq., M.B., C.M., C.I.E., Reporter on Economic Products to the Government of India, to Sir F. A. Abel, Bart., K.C.B., Honorary Secretary and General Director, Imperial Institute, London,—No. 2925—67 F.S., dated Calcutta, the 30th December 1897.

In continuation of my letter No. 2851—67 F. S., dated the 22nd December 1897, on the subject of pine apple (*Ananas sativa*)
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Fibre.	ANANAS sativa.
<p>fibre, I have the honour to forward, herewith, extract from the letter, dated the 18th instant, from the Honourable Mr. J. Buckingham, C.I.E., of Amguri, Assam, for your information, and to add that, although some delay must necessarily occur, it may be expected Mr. Buckingham will ultimately fulfil his engagement.</p>	<p>PROPOSED CULTIVA- TION.</p>
<p><i>Extract from letter, dated the 18th December 1897, from the Honourable Mr. J. Buckingham, C.I.E., Amguri, Assam.</i></p>	
<p>I am much obliged to you for your letter of the 9th instant, regarding pine apple fibre: it is very satisfactory to learn that the fibre is so well reported on. As you observe, it is out of the question getting any quantity now, as the plant must be grown especially for fibre, and not fruit; it is necessary to grow the plants in shade and the fruit under such influence is practically <i>nil</i>.</p>	
<p>I shall at once lay out about 5 acres as an experimental plot. I have enough plants now for at least 3 acres.</p>	
<p>I am much obliged for the help you have given me in this. By all means publish whatever you think fit about the fibre.</p>	

A. 1045-57.

(Agricultural Series, No. 27.)
(Food Substances.)

THE
AGRICULTURAL LEDGER.

1898—No. 12.

—♦—
DAUCUS CAROTA.

(THE CARROT.)

[*Dictionary of Economic Products, Vol. III., D. 173-94.*]

CARROT CULTIVATION AS AN EMERGENT CROP
AT SEASONS OF THREATENED SCARCITY OR FAMINE.

Note on the general conclusions established by the results of the experimental cultivation in the North-Western Provinces and Oudh of Carrots from imported seed during the rabí seasons of 1896-97 and 1897-98.

In the "Famine Commission Report," 1881 (*East India Papers*), Sir Edward Buck, Kt., C.S.I., contributed a note dated 6th October 1878 "on the use of carrots and other root crops by the agricultural population of the North-West Provinces during times of scarcity." The opinion expressed by Sir Edward Buck was that carrots, if sown early enough in the autumn, would probably afford a valuable supplementary food-crop during winter famines in Northern India. After the failure of the *kharif* harvest of 1877 in the North-West Provinces, the cultivation of carrots rose to three or four times the ordinary extent, and would have increased much more had seed been obtainable.

The scarcity of 1896 led to grave apprehensions in official circles, and famine relief measures were established in nearly every district in the country. Another opportunity presented itself of testing the value of a fast-growing root-crop, and practical effect was given to the suggestions of Sir Edward Buck. Accordingly, several tons of "Mediterranean" carrot seed were ordered with as little possible delay from

Introductory.

Sir E. Buck's proposals.

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DAUCUS
Carota.

Carrot Cultivation as an Emergent Crop

Importation
of carrot
seed.

Europe, and on its arrival in India in November it was distributed as widely as circumstances would permit for experimental cultivation in the North-West Provinces.

A memorandum on the details of the purchase in Europe of the carrot seed with observations on the botanical, agricultural and dietetical history of carrots was drawn up by Sir George Birdwood, K.C.I.E. The results of the cultivation in this country of the imported seed are summarised in the following letters submitted to Government by the Director of Land Records and Agriculture, North-Western Provinces.

From J. S. Meston, Esq., Director, Department of Land Records and Agriculture, North-West Provinces and Oudh, to the Secretary to the Government, North-West Provinces and Oudh,—No. 366-C.-VII, dated Naini Tal, the 30th June 1897.

Report of
Director,
Land
Records and
Agriculture,
N.-W. P.

Under the instructions of Government, I have the honour to submit a report on the results obtained with the carrot seed imported from Europe into these Provinces in November and December last. As I did not take over charge of this Department till 23rd April 1897, I have no personal knowledge of the earlier history of the experiment. But the memoranda left by Mr. Moreland, and the reports of District Officers, are supplemented by two full notes prepared by Saiyid Muhammad Hadi, Assistant Director of this Department, and herewith enclosed in original. The great bulk of the work in connection with distributing the seed, keeping the accounts of advances made, and tabulating and testing the results obtained, has fallen on that officer; and I trust Government will recognise the industry, care, and skill he has displayed throughout.

I.—PRELIMINARY.

Scarcity
of 1896.

2. When the weak monsoon of 1896 made the grave failure of the Autumn crops a certainty and raised serious anxiety as to the prospects for the spring harvest, the attention of Government turned to the advantages of quick-growing root crops as an auxiliary source of food-supply. It was recognised that the period of greatest distress would be the months preceding the ripening of the spring harvest, when the Autumn cereals would have become largely exhausted and prices would be at their highest. During this period, carrots are among the most prominent of the food-staples in ordinary use.

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at Seasons of Threatened Scarcity or Famine.

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Carota.

They are sown in late September or early October, come into the market by the 1st of March, and play an important part in supporting the poorer classes till harvesting operations begin.

3. To encourage and make possible a large extension of the area usually devoted to carrots was therefore felt to be a proper and fitting expedient in the scheme of famine relief ; and it was determined to supply large quantities of seed as State agricultural advances wherever cultivators could be induced to sow it. But the amount of seed available in the Indian market fell far short of the indents submitted by District Officers. The carrot is grown almost entirely by the specially skilful castes that practise garden cultivation : there is no demand for seed among the ordinary agricultural classes, and consequently the growers keep little more than is required for their own individual fields. The total amount that Government succeeded in purchasing in the country was somewhat under 40 maunds, or about 1½ tons—utterly insufficient for the requirements of the Provinces. Time was pressing, and an appeal had to be made to foreign markets. Expert gardeners gave their opinion that it was still possible to import European seed and grow it with success. The India Office in England was communicated with by telegram, and with all possible despatch two large consignments of carrot seed were shipped off from London and Marseilles in the end of October and beginning of November.

4. The agents employed by the India Office for the collection and forwarding of the seed were Messrs. Carter & Co., and according to their invoices the quantity despatched and the value of the freights were as below :—

Shipment.	Weight.	Value.	Despatched by—
	Tons. cwt. qrs. lb	£ s. d.	
First . . .	10 0 0 0	750 0 0	} S.S. <i>Peninsular</i> at London.
Second . . .	14 0 0 0	1,000 0 0	
Third . . .	47 9 1 21	2,998 14 5	
Fourth . . .	35 14 1 7	2,440 10 3	S.S. <i>Peninsular</i> at Marseilles.
Supplementary . . .	0 2 0 0	6 17 6	S.S. <i>Himalaya</i> at London.
TOTAL . . .	107 5 3 0	7,196 2 2	

Extension of
carrot
cultivation.

Local supply
insufficient.

Quantity and
value of
imported
seed.

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Carrot Cultivation as an Emergent Crop

Condition of
seed as
despatched.

The seed was of three distinct varieties —large white Mediterranean, large yellow Mediterranean, and large red Mediterranean. A portion of each consignment was cleaned before despatch, but there was no time to clean all the seed, and about 41 per cent. of the total amount reached us uncleaned. The quantities of the different classes of seed as invoiced by Messrs. Carter & Co., are given below :—

Kind of seed.				Amount.			
				Tons	cwt.	qrs.	lb
White	{	Cleaned	.	38	15	3	16
		Uncleaned	.	18	4	2	1
Yellow	{	Cleaned	.	2	1	0	0
		Uncleaned	.	7	13	0	24
Red	{	Cleaned	.	20	16	2	10
		Uncleaned	.	18	13	2	5
Mixed	.	Cleaned	.	1	1	0	0
TOTAL				62	14	1	26
				44	11	1	2
GRAND TOTAL				107	5	3	0

Price.

The price charged on cleaned seed for the first shipment was £75 a ton, raised in the subsequent shipments to £80; for uncleaned seed it was £50 a ton.

Packing.

5. The seed was all packed tightly in sacks. In the majority of cases the original bag was sewn into an outer covering of stout sack-cloth, but in a number of the bags despatched from Marseilles the double covering had to be dispensed with through pressure of time. The protection afforded by the outer sack was considerable; but none of the bags could have been perfectly air-tight or immune from injury in transit. One of the bags in the first consignment, indeed, was so damaged at the London Docks that Messrs. Carter had to send out another one to replace it.

II.—ARRIVAL AND DISTRIBUTION OF THE SEED.

6. The first shipment (59³/₄ tons) of the carrot seed, brought by the S.S. *Peninsular*, reached Cawnpur on 29th November 1896. The season was already far advanced; every day was valuable; and it was imperative that the seed should be at once distributed to the districts requiring it. By previous arrangements made with the

at Seasons of Threatened Scarcity or Famine.

DAUCUS
Carota.

Distribution
in India.

railway authorities this was effected, and the whole consignment was broken up and despatched to different districts by the evening of the day on which it had arrived. There was, of course, no time to weigh it; and the Department had up to then no intimation that the bags contained different varieties of seeds, as it was not till a week later that Mr. Moreland received the Government of India's letter forwarding details of the consignment. The District Officers to whom the seed had been despatched were subsequently asked to weigh the amount received by them, and to distinguish the quantity of the different varieties in their allotment. But in many cases the seed had been mixed and partly distributed before this could be done; and to that account may be laid certain discrepancies in weight which will be mentioned hereafter, and also the scanty information which comes from many districts as to the relative success of the several varieties of carrot grown.

7. The second shipment (47½ tons), *ex S.S. Himalaya*, arrived at Cawnpur on 6th December 1896. The varieties it contained were by this time known, and specimens of each kind of seed were retained for experiments in the Cawnpur Farm. The bulk of the remaining seed was despatched to make up the original indents received from districts, and should have reached the Collectors concerned by 15th December at the latest. (In Bahraich, however, it did not arrive till 19th December.)

Second
shipment.

8. It is unnecessary to tabulate the total amount of seed despatched to each district. Causes, which will be discussed further on, interfered with the full utilization of the seed provided, and large quantities were returned to our granaries at Cawnpur. The amount of seed, however, actually distributed by District Officers is shown in the attached table.* There has been some delay in getting the accounts cleared up, and I am unable at present to locate exactly the small quantity of country seed which was dispensed before Messrs. Carter's consignments arrived. It has accordingly been included in the statement, into which it imports a negligible error of only about 2 per cent., and the districts supplied with country seed have been printed in italics.

Further
distribution.

The prices at which Government has directed the seed advances to be credited in the accounts are Rs50 per maund of cleaned, and

Price of
seed.

* Not reproduced.

DAUCUS
Carota.

Carrot Cultivation as an Emergent Crop

Rs 35 per maund of uncleaned, seed, equivalent to Rs 1-4-0 and 14 annas per *ser*, respectively.

Dates of
sowing and
areas sown.

III.—DATES OF SOWING AND AREA SOWN.

9. On the arrival of the imported seed, sowings were begun with creditable promptitude. It necessarily occupied some little time to have the supply registered, allotted to tahsils, sent out and put in the hands of cultivators. But in the Saháranpur, Pilibhít, Fatehpur, Allahabad, Jhánsi, Benares, Basti, and Bara Banki districts the great bulk of the seed advanced was got into the ground by the end of December. In most of the other districts sowings were over by the middle of January, but in a few scattered cases seed was sown as late as the end of February. General distrust was expressed of the utility of putting down seed after Christmas; but, as the Collector of Allahabad has pointed out, the intercalary month of the Hindu year deluded the cultivators into sowing up to a later date by our calendar than they would otherwise have done.

10. Figures for the area sown are not available. The area under carrots is not extracted separately from that under other garden crops in the *patwáris*' annual papers, and no special survey and record of the imported carrot seed sowings seem to have attempted. In distressed districts the *patwáris* were actively employed in connection with famine relief work; and in other tracts they had partly got through their *rabi* inspection tours before the seed was sown.

The rough estimate made by several District Officers does not go far to take the place of accurate figures. In Hardoi, for instance, 1,533 acres are reported as having been sown with the seed distributed, which was about 95½ maunds in amount; while in Partábgarh 34½ maunds are shown as having served 89 acres. In the Cawnpur Farm experiments the allowance of seed per acre was 12 and 18lb for cleaned and uncleaned seed respectively; but, according to the above figures, it averaged barely 5lb in Hardoi and ran up to 32lb in Partabgarh.

As announced by several District Officers, a certain quantity of the later received seed was held over for planting next season by the cultivators to whom it was advanced. Thus, out of the 1,719 maunds distributed, probably not more than 1,500 maunds were put into the ground. And, if we take 15lb per acre as the average quan-

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Hardoi.

Partabgarh.

Cawnpur.

at Seasons of Threatened Scarcity or Famine.

DAUCUS
Carota.

Areas sown.

tity of seed employed, we get 8,230 acres as a rough estimate of the provincial area devoted to the experiment. Had the result of the sowings been more successful, an attempt would have been made to ascertain more accurate figures of acreage. But as matters stand, it has not been thought proper to ask District Officers for statistics which would be of little practical value ; all that has been asked of them is an estimate of the area on which the crop has failed, with a view to recommending remission of the price with which the cultivators who have suffered have been debited.

IV.—GERMINATION AND TREATMENT OF THE CROP.

Treatment of
the crop.

11. Ideal treatment for the imported seed would have been to put it into good loose soil which had been carefully tilled beforehand to a considerable depth and fertilized by old manure, to sow it in rows, to weed out the plants after germination at several inches interval, and to water from six to eight times between germination and maturity. In the case of the uncleaned seed, it was further strongly recommended that a free mixture of wood ashes should be added before sowing. The actual treatment accorded to the seed was, it is believed, in most cases very different. The seed arrived at a time when all the rich garden land had been taken up by other vegetables and high cultivation. The necessities of the season had concentrated the winter cereals on the best available soil. If outlying lands had been abandoned, every acre within reach of well or canal irrigation had been occupied ; and all the old manure in the villages had been used up for the wheat and cane fields. The carrots had thus to take their chance on mostly inferior soil ; manure, if given at all, was generally fresh and over-rich ; and water could with difficulty and only occasionally be spared for them. The sowings were, moreover, invariably broadcast, and weeding was, according to the country custom, sparingly practised. The admixture of wood ashes was duly enjoined on the cultivators after instructions to that effect arrived from the exporters ; but it was a new idea to most of them and was by no means zealously adopted.

Broadcast
sowing.

12. Germination, which might under favourable conditions have been expected in two or three weeks from sowing, was generally slow ; an interval of four weeks, and in some districts of as much as six weeks, is reported. But the germination was, in the majority

Germination
slow.

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DAUCUS Carota.	Carrot cultivation as an Emergent crop
Treatment of crop.	<p>of districts, fair to good, except in the case of uncleaned seed, with which the special precautions prescribed had been frequently omitted. The sprouting of the seed was in some cases hastened by soaking it in water or milk before sowing ; but my own experience of this method is that, as a preliminary to cultivation in richly manured soil, it is fatal to the after-growth of the plants. The complaints from several districts of the total or partial failure of germination are probably due in part, as surmised by the Assistant Director, to weakness in the uncleaned seed and to unskilful treatment of it. But in many cases the lack of vitality must also be attributed to the seed having been put into hard baked soil, which had been imperfectly prepared for it and was deficient in natural moisture. The theory of inherent flaws in the seed, which would have definitely debarred germination under conditions howsoever favourable, will be discussed in a later part of this report.</p>
Harvesting.	<p style="text-align: center;">V.—HARVESTING AND OUTTURN.</p> <p>13. With late sowings, slow germination, and in most places a scanty supply of water to stimulate growth, the carrot harvest was naturally much delayed. Instead of maturing, as country seed sown at the ordinary time would have done, in early March, the crop was hardly anywhere fit for digging till the last week in April, and in many places it was not taken up till the first half of May.</p> <p>14. The figures of outturn in different districts vary greatly and contain little information of any value as to the comparative success of the different varieties of carrot grown. Appendix B* gives an abstract of the reports received from District Officers, and indicates broadly the general character of the harvest. The information of the reports can fortunately be supplemented by a number of differential experiments made at Cawnpur ; and a summary of the results must be deferred till these experiments are discussed. At present it will suffice to note that, in the hands of the ordinary cultivator, the outturn (with two abnormal exceptions in Allahabad and Mainpuri) is nowhere known to have exceeded 40 maunds an acre. In the majority of cases the produce did not come up to 10 maunds ; and in more than half the reporting districts the crop was either insignificant or entirely lost</p>
Average outturn.	* Not reproduced.

at Seasons of Threatened Scarcity or Famine.	DAUCUS Carota.
<p>15. But this did not exhaust the misfortunes of the harvest. For the quality of the roots obtained was markedly inferior. That they would be individually less bulky than the large and fibrous native variety of carrot was of course expected. But what they wanted in size they failed to make up in succulence. Exceptionally deficient in length and girth, they were also hard and bitter, as a rule unpalatable, and in several districts uneatable except by cattle. As the season wore on and the air and soil got drier, the complaints of bitterness increased, and the later harvested carrots were almost entirely used as fodder. The best carrots that I saw at Cawnpur were distinctly unpleasing to the taste, and the most charitable account given of them is Mr. Brownrigg's, in an interesting statement of his own private experiments, where he describes them as mistaken for fairly good parsnips.</p>	<p>Outturn.</p>
<p>16. In ordinary circumstances the addition to the food-supply from carrot cultivation might reasonably have been anticipated at 200 maunds per acre. Country seeds sown at Cawnpur in October gave a yield of from 200 to close on 500 maunds; and in Saháranpur, from comparatively late November sowings, 50 maunds an acre were secured. The results from the imported seed must, therefore, be taken as having almost everywhere disappointed the hopes entertained of it and failed of the purpose for which it was advanced. How far the failure was due to negligent cultivation, and how far to other causes, may now be examined, the test applied being the comparative results in Cawnpur.</p>	<p>Yield of carrots from country seed.</p>
<p>VI.—THE CAWNPUR EXPERIMENT AND A SUMMARY OF THE PROVINCIAL RESULTS.</p>	
<p>17. The experimental cultivation from the imported seed was conducted under the immediate orders and supervision of Saiyid Muhammad Hadi, the Assistant Director of this Department and a distinguished agriculturist.</p>	<p>Cawnpur experiments.</p>
<p>18. The soil of the experimental plots is throughout good, friable loam (<i>dúmat</i>), adjoining and abutting on the naturally manured zone (<i>gauhan</i>) of one of the Cawnpur suburbs. It has every advantage of canal irrigation, careful tillage, and sufficient manure. The climate is hot and dry, typical of the Lower Doab, and there was next to no frost, even in the midwinter nights.</p>	<p>Character of soil, etc.</p>

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experiments.**Carrot cultivation as an Emergent crop**

19. There were eight experimental blocks, sown in succession from the end of November till the beginning of February, and all treated in different ways. A brief account of each is appended :—

No. 1.—Sown (from the first consignment) on 30th November 1896. No manure. Two weedings and nine waterings. Germinated in two weeks. Harvested in first days of May. Outturn 51 maunds an acre (with white cleaned seed only).

No. 2.—Sown 7th December 1896 with seed of all six varieties. No manure, but richer soil than No. 1. Two weedings and eight waterings. Germinated in three weeks. Harvested on 27th April 1897. Outturn—for uncleaned seed below 24 maunds ; for white yellow, and red cleaned, 64 maunds, $74\frac{1}{2}$ maunds and 37 maunds, respectively.

No. 3.—Sown on $\frac{17}{18}$ th December 1896 with all six varieties and in three different methods. Two weedings and six waterings. Rich naturally manured soil. Germinated in a fortnight. Harvested in last week of April. Broadcast sowings a failure except with red uncleaned seed (66 maunds). Sown in drills, white and yellow uncleaned seed failed, but all red seed did well (76 to 81 maunds), and white cleaned gave 109 maunds ; sown on ridges, the results were similar, but yellow cleaned gave 136 maunds. These were the best results in the whole series of experiments.

No. 4.—Sown on 20th December 1896 with all six varieties. Manured with poudrette ; one weeding and five waterings. Harvested in last week of April. White and yellow uncleaned seed a failure ; red seed, about 31 maunds white cleaned, $60\frac{1}{2}$ maunds per acre.

No. 5.—Sown on 25th December 1896 and treated exactly like No. 4. Harvested 19th to 22nd April. Uncleaned white and yellow seed failed ; red seed, 39 maunds (cleaned) to 60 maunds (uncleaned) ; cleaned white and yellow, 49 and 59 maunds, respectively.

No. 6.—Sown on 31st December 1896 with cleaned seed only. Treated like Nos. 4 and 5. Harvested 30th April 1897. Outturn nowhere up to 24 maunds.

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No. 7.—Sown on 24th December 1896 and 4th January 1897 with cleaned seed only. Treated in every way as a native cultivator would have worked. Harvested 2nd May. Outturn nowhere up to four maunds an acre.

No. 8.—Sown on 12th January 1897 on manured land. Not harvested, as roots thin, hard, and unfit for food.

20. Experiments Nos. 3 and 7 are the most interesting of the series. No. 3 shows the importance of cultivating the carrot on the rich circum-hamlet zone (*gauhan*), which is the natural habitat of garden crops. It illustrates also the superiority of sowings in drills and on ridges to the native method of broadcast sowing, which was adopted in all the other experiments. No. 7, on the other hand, exhibits the true indigenous conservative methods. The land was old fallow, such as the cultivator might have selected after all his best land had been occupied by *rabi* crops. The seed was sown broadcast. The country plough and field hoe were used. Irrigation was given from a well four times, being about as often as the ordinary cultivator could afford water. And a liberal, but injudicious, supply of cowdung manure was provided, being the best the ordinary cultivator would have done for the crop. The sowing took place about the time at which most of the imported seed throughout the provinces was laid down, and the crop was dug up in early May. The outturn did not exceed four maunds an acre; if the seed had not been badly choked by weeds, it might have yielded up to 10 maunds.

Broadcast
sowing.

Irrigation.

Manure.

Yield.

21. The average outturn of the various types of seed in the first seven plots is quoted in Part (b) of Appendix C.* The striking inferiority of the uncleaned seed of the white and yellow varieties led the Assistant Director to consult the Botanical Department; and I have just received from Mr. Gollan an interesting note of a test applied by him at Mussoorie. He put down 200 seeds of each variety in pots during the current month, and up to 25th instant the germination had been—

Mr. Gollan's
germination
tests.

White, cleaned	.	.	.	.	.	.	63 plants.
„ uncleaned	.	.	.	.	.	.	3 „
Yellow, cleaned	114 „
„ uncleaned	Nil.
Red, uncleaned	113 plants.

* Not reproduced.

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Provincial
Results.**

Mr. Gollan promises to write again after giving the seed a longer trial, and his further report will be submitted to Government on arrival.

22. Collating now the information from districts with our experience at Cawnpur, we may thus summarize the general results of carrot cultivation from imported seed :—

- (a) The seed, despite all due diligence, was not in the hands of District Officers till December, being from $1\frac{1}{2}$ to $2\frac{1}{2}$ months after the ordinary time of sowing country seed.
- (b) Chiefly owing to this cause, only about 1,700 maunds were distributed as advances ; and of that amount probably about 1,500 maunds were sown, the rest being held over for next season.
- (c) Sowings are made, as far as possible, in December ; but in several districts they were delayed into the first half of January, and there were a few isolated cases of even later sowings. Germination occurred in from a fortnight to six weeks.
- (d) The harvest was late (end of April and beginning of May), and the carrots that came to maturity were generally hard and unpalatable, getting worse the longer they remained in the ground. The roots, except where freely weeded, were extremely defective in girth and length.
- (e) The outturn was everywhere indifferent, and in many cases it failed altogether. Out of the 36 districts that have definitely reported on the subject, 22 had virtually no crop at all ; in seven the produce averaged less than 4 maunds ; in two less than 10 maunds ; and in only five did it range from 10 to 40 maunds an acre.

**Comparative
methods.**

Turning to localities and comparative methods of culture and varieties of seed, we may continue :

- (f) Moderate success with the crop was attained in the Doab districts and Rohilkhand. In Bundelkhand, where it was most needed, it failed entirely : and in the eastern districts of the North-West Provinces and in Oudh the harvest, where there was any at all, was of the poorest.

at Seasons of Threatened Scarcity or Famine.	DAUCUS Carota.
<p>(g) The indigenous method or broadcast sowing proved utterly unsuitable to the seed : but even with the best agricultural skill at the disposal of Government, the outturn did not get beyond a third of the produce given by country seed planted in October.</p> <p>(h) Seed sown from 1st to 30th December was fairly productive. Thereafter, the results got worse as the season advanced.</p> <p>(i) Irrigation and manure were essential to the seed ; but fresh manure applied in the ordinary country fashion was useless or harmful.</p> <p>(j) Of the different varieties, the large yellow Mediterranean gave the highest individual crop on both manured and unmanured land, as well as the best average outturn ; but the roots were coarse, hard, and unpalatable. The white variety came next in weight, but the carrots were coarser even than the yellow ones. The red variety, though giving the lightest crop, was edible and fairly sweet.</p> <p>(k) The germination of the uncleaned seed of the white and yellow varieties was strikingly defective ; and the vitality of a large quantity of it is doubtful. Of the red variety the uncleaned seed did quite as well as the cleaned, and frequently better.</p> <p style="text-align: center;">* * * * *</p>	<p>Comparative methods.</p>

VIII.—GENERAL REVIEW OF THE POSITION.

26. The effort to grow European carrots on a large scale as a supplementary food-crop during a period of famine must on this occasion be acknowledged as having been frustrated. The crop failed almost entirely in the most distressed districts ; and in the few tracts where it attained any success, its gross addition to the food-supply was comparatively insignificant. The roots, when harvested, proved to be coarse in quality and defective in nutriment, and by the time they reached maturity the period of greatest strain had passed and the spring cereals were coming into the market.

How it came to pass that the intentions of Government were thus defeated, notwithstanding the constant use and the unquestioned value of the country carrot as a food-staple, is the question I now

General
Results.

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Causes of
failure.

propose briefly to discuss. The probable causes of failure may be classed under four heads :

- (a) the quality of the seed ;
- (b) the unwillingness of the people to use it ;
- (c) the time of sowing ; and
- (d) the conditions of cultivation.

General
results.

27. (a) There is a general and clear consensus of opinion that the uncleaned seed of the white and yellow varieties was distinctly inferior. It was given every advantage of skilful cultivation at Cawnpur, and its results were in striking contrast to those given by cleaned seed of the same varieties as well as by the uncleaned red seed. At the risk of repetition, the Assistant Director's figures are quoted below to enforce the comparison :—

Kind of seed.		Produce in maunds on plot No.—						REMARKS.
		II.	IIIa.	IIIb.	IIIc.	IV.	V.	
White {	Cleaned .	64 $\frac{1}{3}$	27	109	72 $\frac{1}{2}$	60 $\frac{1}{2}$	49	
	Uncleaned .	23 $\frac{1}{2}$	2	12	23 $\frac{1}{2}$	8	8	
Yellow {	Cleaned .	74 $\frac{1}{2}$	21	74 $\frac{1}{2}$	136	29	59	
	Uncleaned .	20 $\frac{1}{4}$	1	11 $\frac{1}{4}$	24 $\frac{1}{4}$	10 $\frac{1}{8}$	4	
Red .	Uncleaned .	23 $\frac{1}{2}$	66 $\frac{1}{2}$	76	51 $\frac{1}{4}$	30 $\frac{1}{4}$	60	

The result of the germination trial made by Mr. Gollan at Mussoorie is further evidence of the want of vitality in the uncleaned white and yellow seed. The Assistant Director, in Part VIII of his General Note, gives his reasons for considering that the bags of uncleaned white and yellow contained a large proportion of immature seed, taken in all probability from the lateral shoots of the carrot plant, gathered prematurely and incapable of germination.

Immature
seed
imported.

The Assistant Director conjectures that the large and sudden demand for seed may have led to considerable crops of seed carrots being cut and threshed, ripe and unripe together. From the correspondence with the India Office it would appear that Messrs. Carter & Co. had not entirely completed their purchases before the Government of India came into the market : and it is just probable that the maturity of the white and yellow uncleaned seed (which came wholly in the second shipload and largely from Marseilles) may not have been fully tested before despatch.

It was hoped that a microscopical examination of the seed would elicit the cause of defective germination, and specimens of the

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different varieties were accordingly submitted to Mr. Duthie, Director of the Botanical Department, Northern India. Mr. Duthie has, however, been unable to detect any difference in the structure and condition of the individual specimens sent to him: and he has written to say that he considers germination trials to be the only true test of the vitality of the seed.

As both in these trials and in the actual outturn the white and yellow uncleaned seed has done extremely badly, it now only remains to suggest that Government should move the India Office to ascertain from their agents the probable cause of the failure of those particular varieties.

28. That the seed generally suffered by being despatched to India in sacks instead of in hermetically sealed cases is a theory that has been advanced from several quarters. It was broached in an editorial note in the March issue of *The Indian Agriculturist* (page 71); it has been alluded to by Mr. Duthie as a probable cause of bad germination; and it has been suggested by several District Officers. Carrot seed is notoriously delicate, and every precaution is taken by private seeds-men to protect it from air and damp. That the sea voyage was injurious to it, packed as it was, is therefore an intrinsically probable theory; but there is no evidence to support it. The seed, as far as we can gather, lost weight by shrinkage on the journey from Europe to Cawnpur; if it had suffered by sea voyage, it would probably have absorbed moisture and gained weight. It looked fresh and sound when the bags were opened; and the germination of the cleaned (and red uncleaned) seed was everywhere satisfactory, arguing against the theory of any extensive damage in transit. But even supposing the evidence had gone the other way, it is questionable whether responsibility for the damage would have attached to the consignors. Any attempt to hermetically seal 108 tons must have meant a delay in shipment that would necessarily have been fatal to the whole scheme.

29. (b) The unwillingness of the people to take the seed is complained of by several District Officers, and resulted in more than a third of the quantity indented for being returned upon our hands. This attitude was the product of various causes. The delay in receiving the seed was the chief of them; the cultivator has little regard for expert opinion and was satisfied that seed sown six weeks

Carrot seed
not hardy.

Seed not
appreciated
by culti-
vators.

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after the normal date was doomed to failure. The price of the seed was grumbled at; four annas a *ser* had been in ordinary years the bazar rate for country seed, and though last year it had run up to 12 annas and over, and then disappeared from the market altogether, the cultivator haggled against the rates of advance offered by Government. Then, again, the use of European carrot seed was a novelty: and with the poorer classes *ignoti nulla cupido* is truer than ever in a famine year. And, finally, in one district (Ghazipur) the Collector found religious objections urged against the experiment, though their nature is not stated.

Delay in
sowing.

30. (c) Delay in planting the seed was after all what handicapped the scheme most severely. That the people were willing enough to extend their sowings at the usual season is manifest; estimates from several districts show that the area in country carrots in 1896 was very greatly above the normal, and the results were evidently successful. That imported seed, if available in October, would have been readily taken up and grown with fair success can scarcely be questioned. From our Cawnpur experiments it is apparent that the English seed, planted even up to 20th December on suitable soil, gave reasonably good returns and would have materially supplemented the food-supply, though it could scarcely have been brought on the market before the *rabi* harvest. But every day of delay after the middle of December meant a dwindling outturn and deterioration in the quality of the roots. And delay to some extent was inevitable. It was not till the first half of the month that the consignments reached District Officers, and the distribution was hampered by the backwardness of cultivators to apply for it.

Untimeliness
of the
season.

The late dates of sowing had other effects than the mere untimeliness of the season. Long before December, the land usually devoted to garden cultivation had been occupied, and every effort had been strained to put all the best outlying soil under *rabi* crops. Tillage was concentrated round all the available sources of irrigation; and fallows in good land meant the powerlessness of the cultivator to work it, come his seed whence it may. The carrot required rich natural soil and free irrigation: and by the time seed could be imported, those conditions were in very many cases unattainable. When the seed was eventually put down, all the scanty moisture left by the monsoon had evaporated. And ere it germinated, the dryness of the

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Results.

air and hardness of the soil were not to be counteracted by artificial irrigation. To these causes was due the hard and bitter quality of the roots when they came to maturity.

31. (d) In the matter of careful and intelligent cultivation, the imported seed did not in many places get a fair chance. That any skill of tillage would have saved the late sown seed, especially in the eastern part of the provinces, seems doubtful, as witness the experiments made by Mr. Bird at Muttra, Mr. Browrrigg at Sultanpur, and Mr. Cobb at Benares. But individual instances of successful work under favourable conditions are noted by the Assistant Director. Improved methods at Cawnpur gave reasonably good results: and the intelligent cultivators of the Doab showed that a fair outturn was possible. The fact remains, however, that in the hands of the ordinary cultivator, unpractised in market gardening, indigenous systems of treatment are apt to fail with the delicate seed of the European carrot. The sowings are made broadcast on level plots, while ridge and furrow sowings are essential to success. Weeding is rarely employed, however thickly the plants may germinate: the cultivator shrinks from the seeming waste of freely thinning his field, and substitutes a process of shaving off the leaves, which only tends to toughen the roots. Manure, if applied, is generally fresh and over-rich, causing the "forking" deformity to appear in the carrot; and irrigation is not always judiciously regulated.

Vegetable
cultivators
versus
common
husbandmen.

With the special castes that practise vegetable cultivation, the treatment, if similar in its general lines, is more careful and successful. If our imported seed had found its way entirely into their hands and got a place in their small, highly tilled holdings, the results would have been very different from what they are. As it is, the seed was largely taken up by ignorant husbandmen, who had to work it by primitive methods and mostly on inferior, outlying and imperfectly irrigable soil. To this were added the disadvantages of a particularly inclement season and a certain indifference among the cultivators as to the success of the experiment.

Red Medi-
terranean
the better
variety.

32. To the above summary of the causes that have interfered with the success on this occasion of European carrots as a famine food, there is little to be added. It may reasonably be concluded that imported seed—by preference of the large red Mediterranean variety—will succeed quite as well as country seed if put into the

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hands of skilful cultivators by October. If the right classes of husbandmen get the seed, with simple directions as to its treatment, they will almost certainly be able to put a larger supply of food on the market than the gross amount which the general cultivator could raise for himself on his own land by indigenous methods : and should, unfortunately, the necessity again arise for the experiment, it is hoped that, with the knowledge now acquired, this Department will be able to give effectual assistance in executing the intentions of Government.

Further
information
asked for.

The Government of the North-West Provinces in acknowledging the above report requested that further information might be furnished on the following points :—

- (1) the amount of seed actually planted before the end of November, and the weight and character of roots harvested ;
- (2) the amount actually planted before December 10th, and the weight and character of roots harvested ;
- (3) the amount planted up to the end of December, and the weight and character of roots harvested ;
- (4) the amount planted after the end of December, and the amount and character of roots harvested.

The Director after referring to the reports of the District Officers reviewed the returns under the following heads (1) The area sown ; (2) The quantity of seed sown per acre ; (3) Dates of sowing ; (4) Outturn. From these statistics the following statement was prepared which afforded an approximate answer to the questions in the Government Order :—

Amount of
seed planted.

- (1) The amount of seed planted before the end of November—*nil*.
- (2) The amount of seed planted before December 10th—230 maunds. The weight of roots harvested therefrom—25,095 maunds. The character of the roots—about 3,000 maunds fairly edible, though thin and defective in girth ; the remainder edible, but bitter and unpleasant to the taste.

Character
of roots
harvested.

- (3) The amount of seed planted from 11th to 31st December—562 maunds. The weight of roots harvested therefrom—42,745 maunds. The character of the roots—about 10,000 maunds still edible, but hard, thin, pungent and with a coarse, fibrous core occupying the most of their bulk ; the remainder coarse and unfitted for human food.

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carota.

Character
of roots.

- (4) The amount of seed planted after 31st December—608 maunds. The weight of roots harvested therefrom—6,870 maunds. Acrid and uneatable, except by cattle.

The Director's interesting remarks on the character of the roots harvested indicate a considerable disparity between them and the well-known vegetable as ordinarily supplied by market gardeners. "According to the unanimous opinion of all the District Officers the carrots grown from seed sown after Christmas were hard, thin, and completely unpalatable, fit only for feeding cattle upon. Those grown from seed planted in the earlier part of December were small and bitter: at their best they were stringy, with a fibrous, inedible core and a taste like indifferent parsnips. Their succulence, too, varied according to the class of seed, the red variety being fairly sweet and the white invariably coarse. It differed, too, with the soil and place of growth, the plants, for instance, on the ridges along irrigation channels being juicier and fleshier than elsewhere. In the Cawnpur Farm I saw some edible carrots of fairly normal size, and in Basti I was informed that the carrots were eaten with approval; but all the carrots I got in Bareilly and Lucknow were in length and girth like a lead pencil, and in taste acrid and repellant. It is thus impossible to generalize as to the character of the roots grown at particular times."

The following analyses of two samples of carrots (white and red) grown on the *usar* land, Gursikram and Aligarh, during the *rabi* season 1896-97 were made by Dr. J. W. Leather, Agricultural Chemist to the Government of India. By the side is placed the report of an analysis of carrot root given in *Cooley's Cyclopædia*, 1892. The composition of the roots grown in India and in England does not exhibit much variation.

Chemical
analyses
of carrots.

	White carrots.	Red. carrots.	English carrots.
Water	84.57	84.43	87.30
Soluble albuminoids . . . . .	.35	.48	} .66
Insoluble „ . . . . .	.17	.30	
Sugar, starch, etc.	8.98	7.98	8.10
Crude fibre	2.37	3.70	} 3.20
Woody „	2.19	1.80	
Soluble mineral matter	1.09	.99	} .74
Insoluble „28	.32	
Total	100.00	100.00	100.00
Total Nitrogen175	.230	

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Carota.Final
experiments
at Cawnpur.

Carrot Cultivation as an Emergent Crop

The final report on the experimental cultivation of the seed during the ensuing cold weather of 1897-98 is of much interest, and the conclusions will be of considerable value in the event of the experiment being repeated.

From J. S. Meston, Esq., Director of Land Records and Agriculture, North-West Provinces and Oudh, to Chief Secretary to Government, North-West Provinces and Oudh,—No. 492C., dated the 24th May 1898.

In compliance with G. O. No. $\frac{2459}{S.-89}$ of 12th November 1897, I have the honour to submit a brief report on the experimental cultivation of carrots from imported seed which was carried out at Cawnpur during the past cold weather.

2. The Government of India, in a telegram to the Local Government in last November, desired us “to ascertain how far seed would have succeeded if supplied in time,” and suggested that, “thorough trial should be given to the seed under various conditions under which it would have to be sown to be of use in famine.” More than a month before the receipt of this telegram, experiments having these objects in view had been started at the Cawnpur Government Farm; and very large quantities of imported seed had been distributed to District Officers and private individuals. As far as my enquiries have gone, I believe that the experience of the great majority of the cultivators who took the seed in September and October 1897 has been very much like our own experience at the Cawnpur Farm and Gardens. I have not, therefore, thought it necessary to trouble District Officers for reports which would only give with less precision results similar to those described by the Assistant Director.

3. The Cawnpur experiments were intended to decide—

- (a) the most suitable dates for sowing imported seed;
- (b) the most appropriate methods of cultivation; and
- (c) the quality and quantity of the outturn of the different varieties of imported seed as compared with each other and with country seed.

4. The experiments, though not conclusive in every detail, allow of these questions being answered as below with reasonable confidence :—

- (a) The proper time for sowing imported carrot seed is from the middle of September till the middle of October. After the latter date the sowings get less and less produc-

Time of
sowing.

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at Seasons of Threatened Scarcity or Famine.

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tive, and if they are left over till November, their yield is, under ordinary conditions, of little or no value.

Conclusions
from
Cawnpur
experiments.

- (b) The crop requires to be irrigated and fairly plentifully manured. At the Farm, where our best results were obtained, six to nine waterings were given between germination and maturity, and manure was provided at the rate of 200 maunds per acre. On unmanured land the outturn was exceedingly poor, and last year's experiences proved the futility of trying to grow the crop without irrigation. Sowings on ridges met, on the whole, with better success than the ordinary country method of broadcast sowing, though on poor soil and with defective irrigation the superiority would apparently disappear. The general conclusion to be drawn from the experiments is that the cultivation of imported carrot seed is more suitable for the minute skill of the market gardening classes than for the broader style of work displayed by the ordinary cultivator. This is of course nothing new; but it may be taken as a recommendation against advancing carrot seed to a cultivator in future, unless he can guarantee manured soil, irrigation, and reasonable care for its tillage.

Irrigation
and manure
necessary.

- (c) A comparison of the results obtained from the different varieties of seed received from Europe places it beyond doubt that the uncleaned seed, on the whole, was markedly defective in germinating power. This fact, when stated in previous reports, was questioned by Messrs. Carter & Co.; but we have made it the subject of most careful trials and observations, and we are fully confirmed in the conclusions formerly expressed. Last year we found the red uncleaned variety to possess reasonable vitality; but the white and yellow uncleaned seed gave almost uniformly bad yields. This year they have still further deteriorated, and their outturn has been almost negligible. Without any discussion as to the cause of this phenomenon, it may be safely recommended that in future no seed be imported unless the dealers are able to clean it before despatch and to guarantee it mature.

Cleaned and
matured seed
only to be
sown.

**DAUCUS
Carota.****Carrot Cultivation as an Emergent Crop**Conclusions
from
Cawnpur
experiments.Varieties
compared.

Red.

Yellow.

White.

Cleaned
seed best for
transport.

Of the three varieties of cleaned seed which we received, red, white, and yellow Mediterranean, the first was clearly the best. Its yield, under high cultivation, was about the same as that of the country carrot, and the root was extremely sweet, palatable, and nutritious. The white Mediterranean variety gave under high cultivation better yields than the country carrot, but the roots were hard and coarse. The yellow Mediterranean was even more prolific than the white, though individual roots did not reach the remarkable dimensions attained by many of the white carrots, but its produce was equally unsuitable for human consumption. On unmanured ground the yellow variety did much better than the others ; but without the aid of manure it was far behind the country carrot. It may be taken, then, that the yellow carrot is the hardiest of the three varieties and is fairly well suited for cultivation as a cattle food ; while, on the other hand, the red carrot is best adapted for cultivation as a supplement to the human food-supply.

5. One interesting result of the experiments now reported has been to show that the cleaned seed did not suffer materially for not being hermetically sealed before its despatch from England. The shipping of the seed in sacks was unfavourably commented on by critics both in and outside the administration ; but there is no proof that any damage resulted from this method of transit. The test was a severe one, a sea voyage from London and Marseilles to Bombay being followed by months of exposure to the air during the cold weather of 1896-97 and by storage during the succeeding hot weather and rains ; but in spite of all this the germinating power of the seed cannot be said to have been materially impaired.

6. The following general conclusions may thus be recorded for guidance in the event of its being necessary at any future time to advance imported carrot seed for cultivation as a famine relief measure :—

- (i) The seed must be cleaned before despatch, and it must be mature.
- (ii) The red Mediterranean variety should be obtained by preference ; failing it, the yellow variety, though the latter is more suitable as food for cattle than for human beings.
- (iii) The seed need not be hermetically sealed for transit from Europe ; careful packing in double sacks will protect it from harm during the voyage.

D. 173-94.

at Seasons of Threatened Scarcity or Famine.	DAUCUS Carota.
<p>(iv) The seed must reach these provinces not later than 1st October ; to allow of careful and timely distribution, we ought, if possible, to get it by 15th September.</p> <p>(v) The seed must receive careful watering and manuring, and it should, whenever possible, be entrusted to the castes who are specially expert in market gardening and high cultivation.</p>	<p>Conclusions.</p>

D. 173-94.

G. I. C. P. O.—No. 184 R. & A.—3-11-93.—2,225.—H. R .

(Crop Disease and Pest Series, No. 3.)

THE
AGRICULTURAL LEDGER.

1898—No. 13.

SUGAR-CANE DISEASE.

(TRICHOSPHERIA SACCHARI, Mass.)

[*Dictionary of Economic Products, Vol. VI., Pt. II., S. 176-93.*]

An Account of the Fungal Disease attacking Sugar-cane in the West Indies, together with Remedial Measures recommended by the Authorities of the Royal Gardens, Kew. Concluding with DR. BOURNE'S Report on the Occurrence of the Disease in the Godáviri deltas.

The Government of India realising the danger of the recently discovered fungal disease in the sugar-cane of the Godáviri delta and the necessity of observing every precaution, have desired that a complete Ledger be prepared on the subject. In accordance with the request, the following information has been drawn up chiefly with the aid of the *Bulletins* issued by the authorities of the Royal Gardens, Kew. The references include a general description of the disease as observed by the cultivators; Mr. Massee's reports on the two polymorphic forms of **Trichosphæria**; the remedial measures recommended by planters and experts; and, finally, the accounts of the occurrence of the blight in India.

INTRODUC-
TORY.

Trichosphæria Sacchari, Mass.

Synonyms.—*Rind fungus. Root disease, red patch, red smut or Rood Snot (Dutch) the "sereh" or sugar-cane disease of Java, is referred to COLLETOTRICHUM FALCATUM, Went, pronounced*

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TRICHOS-
PHÆRIA
SACCHARI.

Synonyms.

References.

DISTRIBU-
TION.

India.

Australa.

Mauritius.

Barbados.

to be nothing more than a condition of TRICHOSPHERIA. "Pine-apple disease of the sugar-cane," THIELAVIOPSIS ETHACETICUS, Went, appears to be identical with the macro-and micro-conidial stage of TRICHOSPHERIA. STRUMELLA SACCHARI, Cooke, described from Queensland. TRULLULA SACCHARI, Ellis and Everhart, *Journ. Inst. of Jamaica*, Vol. 1. (1892), p. 159.

References.—Mr. George Masee* *Annals of Botany*, Vol. VII., Dec. 1893, p. 515; Dr. N. A. Cobb,† *Diseases of the Sugar-cane in Agricultural Gazette of New South Wales*, Vol. IV., Pt. 10, p. 800, figs. 17—19, Sydney, 1893; *Kew Bulletin*, July 1893, p. 149; Dec., p. 345; March 1894, p. 81; May, p. 154; June, p. 169; Apl. and May 1895, p. 81; May and June 1896, p. 106; Dr. F. A. F. C. Went,‡ *Mededeelingen van het Proefstation, West Java*, 1893; *Het Rood Snot* (H. van Ingen Soerabaia, 1893) *Notes on Sugar-cane Diseases*, 1897.

Distribution.—The sugar-cane disease which has produced such distressing results in the West Indies during the past few years is supposed to have been introduced from the East. A fungal blight had been observed in the cane plantations of India, Java, Borneo, Queensland, and New South Wales, and in 1893, simultaneously, with the outbreak in the West Indies, it made its appearance in Mauritius.

The cultivation and production of sugar provides subsistence for so large a proportion of the population of the Colonies that the malady was regarded as serious. The disease was first reported from Barbados by Mr. J. R. Bovell, Superintendent of the Botanical Station at Dodd's Reformatory. (*Kew Bulletin*, July, 1893, p. 150). The two forms of the blight—the rind and root stages—were observed in the same year, and the disease was still spreading in 1895, (*Kew Bulletin*, 1895, p. 87). Mr. J. H. Hart, Superintendent, Botanic Gardens, had previously forwarded samples of diseased canes from

* Principal Assistant (*Cryptogams*) in the Herbarium of the Royal Gardens, Kew.

† Pathologist to the Department of Agriculture, New South Wales.

‡ Professor of Botany in the University of Utrecht, formerly Director of the West Java Sugar Experimental Station.

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disease.

Trinidad. In July 1894, specimens of the root disease were obtained by Mr. Bovell, in St. Vincent, and sent for examination to Kew (*Kew Bulletin*, June 1894, p. 175). News was received in 1893, that the disease had wrought terrible havoc in some of the estates in Grenada, and from Antigua it was reported that the "whole atmosphere was saturated with the spores" (*Kew Bulletin*, 1894, p. 176). Mr. C. A. Barber, F.L.S., Superintendent of Agriculture, Leeward Islands, on the 16th April 1894 reported to his Government—"The fungus (*Trichosphæria*) is our greatest enemy." In the same year, the disease appeared in British Guiana and made rapid progress through the Colony.

With regard to India, *Trichosphæria* was noticed on specimens of sugar-cane received from Saharanpur, North-West Provinces, in 1892 (*Kew Bulletin*, 1894, p. 83). In 1896, the canes in the district of Muzaffarnagar were badly attacked, although, strange to say, it had occurred in a mild form for two or three seasons previously without exciting much attention. Its appearance in the Godávári district of the Madras Presidency, and the remedies suggested for its eradication are discussed by Dr. Bourne whose report is appended to this article.

The disease may now be regarded as cosmopolitan, and perhaps it is not too much to assume that it is present in greater or less abundance wherever the sugar-cane is cultivated.

GENERAL DESCRIPTION.

Before describing the special characters of the fungal disease which has attacked the sugar plantations of both the Old and the New World, it will be desirable to refer to the general appearance and symptoms as observed by the cultivators.

The following extracts taken from the *Kew Bulletin* afford the most authentic information on the subject and give a graphic account of the destructive effects of the disease. The first extract is taken from a Report of the Commission appointed by His Excellency the Governor of Barbados (Sir James Shaw Hay, K.C.M.G.) to enquire into and report upon the best means of destroying the borer and other pests affecting sugar-cane. (See *Kew Bulletin*, April and May 1895, p. 81.)

"In riding round the margin of a canefield, canes infected with the rind fungus are first noticed by dark red or brown marks, in one or

DISTRIBUTION.

St. Vincent.

Antigua.

Leeward Islands.

British Guiana.

N.-W. Provinces.

Madras.
Conf. with
p. 17.

GENERAL DESCRIPTION.

Report of
Barbados
Commission.

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DESCRIPTION

two joints towards the middle or base of the cane. These marks are easily distinguished from sun-burn because of their diffused character, indistinct edges, and by its being evident that they are not mere surface stains, but that the tissues beneath are affected. This "Red patch" on the canes is first noticed in July, and from October onwards gradually becomes more and more abundant up to the time of the ripening of the canes. It is by no means found only in poor-looking canes, but is often present in fine-looking plants. This red patch having made its appearance, rapidly spreads upwards and downwards, the infected area darkens in appearance, and is evidently rotten. Little black specks make their appearance, breaking from the inside to the surface of the cane, being first seen in the sleeping roots near the joints, and then at the parts of the cane between the joints, finally the cane shrivels and dries up.

Reduces the
Yield of
Sugar.

"The result of this disease is that canes which, if they had remained healthy, would have given a large yield of rich juice, are found to be absolutely valueless, and so far from themselves yielding sugar, their presence amongst crushed canes actually leads to a marked deterioration of the juice and of the sugar manufactured therefrom, as well as to a diminution in the quantity of the sugar obtained.

Outlook
serious.

"This disease is present in probably every canefield in the island, and the total crop of 1894 is clearly found to be very seriously diminished by it. And your Commission have formed, after the most careful consideration, the very disquieting opinion that if it be left unchecked the cultivation of the sugar-cane will be rendered unprofitable, and therefore extinct in this island. With the present outlook as regards prices and production, it is evident that if sugar-cane cultivation is to remain the staple of the island, large crops must be maintained at a minimum cultivation cost, and this cannot possibly be accomplished in the presence of any serious amount of disease.

Fungus and
Moth Borer.

"*Rind Fungus and Moth Borer (Chilo saccharalis).*— From the appearance it would seem that the rind disease in at all events a large number of cases started from the burrow of the Moth Borer. It would seem that in Barbados up to, say, December in each year the fungus makes an entrance into the cane at spots injured by the Moth Borer, which must, therefore, be looked upon as a very serious insect pest.

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disease.

"From January onwards, however, an increasing number of canes will be found attacked by rind fungus, and without any signs of Borer whatever. From a careful examination of such canes it would appear that the attack had started from the middle or base of the cane as the fungus is most mature there, first sending out the black specks (which are spores or seeds) in those portions. These cases of canes attacked by fungus alone are very serious, because they increase with the ripening of the cane, and in March and onwards become so numerous that they constitute, we think, a large majority of the diseased canes. These canes are frequently found red from end to end and rotten or dry and shrivelled up from end to end without any sign of Borer whatever. It would appear from Mr. Massee's very comprehensive and able paper that the fungus in such instances must have effected an entrance at the ragged bases of the old leaves which have been torn or broken off. The above facts show the fungus to be a pest which can by itself and without any previous insect injury attack the cane; consequently, a pest to be dealt with in addition to any measures which might be adopted to exterminate the Moth Borer.

"**Root Fungus.**—For the present, we leave the subject of rind fungus to deal with that of "*root fungus*" so called; specimens of which have also been examined and reported upon by Mr. Massee, who determined it to be a fungus known as *Colletotrichum falcatum*, a species recently described by Dr. Went as injuring the canes at Java.

"The characteristics of this disease, as far as we have examined it, are as follows:—

- (1) It was at first confined for the most part to the higher red soils of St. John, having only appeared in small patches in a very few other places, but has since spread in spots all over the island.
- (2) The effect of this disease is that the canes appear to receive a check in their growth about June and July after planting; the plant dwindles down, fresh basal shoots are formed to supply the place of the dying ones, but notwithstanding this it is ultimately found that growth has been arrested and no cane formed; and if the plant be dug up, the roots are nearly all dead; and those that are still living are dotted

GENERAL
DESCRIPTION

Appearance
of Diseased
Canes.

Root Fungus.

Found in
Java.

CHARACTER-
ISTICS.

Canes stunted
in growth.

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disease.

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(SUMMARY.)

over by little red spots. The dead roots are also often covered by mildew.

(3) Such canes yield practically no sugar, and the crop of a thoroughly diseased field is practically nothing.

(4) There seems to be some resemblance between this disease and the Sereh of Java. In the latter disease we have the same retardation of growth, and shortness of joints, a greater number of dead roots, an attempt to throw out new shoots from the stool to replace those above that are dead. In Sereh, as in the St. John's disease, there is a gradual dying away of the plant after the commencement of the rainy season.

Loss of sugar.

Sereh disease
of Java.

The one characteristic (histological) of Sereh is the presence of a gelatinous substance, slime or gum, in the fibro-vascular bundles of the cane, giving the parts attacked a red colour.

"It has been finally decided at Kew that *Colletotrichum falcatum*, *Went*, is simply one phase in the life history of *Trichosphæria Sacchari*, *Mass.*, and that the phenomena above described are the effects of that particular phase of the disease.

Selection of
canes for
planting.

"*Selected Cane Plants.*—It is difficult to form a decided opinion with regard to the part played by carelessly selected cane plants in propagating rind fungus. The attack appears so late in the life of the cane that it is difficult to suppose that careless selection has been the direct cause of the presence of fungus spores. It is almost equally difficult to speak with regard to the propagation of Moth Borer. This insect, as well as the fungus, appears to be more prevalent in the low than in the high lands, and it may be that the better shelter from winds in the former districts enables it to settle more effectively and prevents dispersion. On the other hand, in recent years it often happens on every estate that a larger or smaller number of cane plants fail to germinate or die off almost immediately after germination.

Use of
diseased
canes to be
avoided.

"At all events, in some cases this is due to diseased plants, and it seems exceedingly probable that the high number of supplies on some estates has been partly due to that cause. The disease is sometimes due to the Moth Borer and sometimes due to fungus. In this connexion, an interesting experiment is recorded by a planter of this island, who planted 2,900 healthy Keni Keni plants from a

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healthy field, and 2,850 Keni Keni plants selected carefully by labourers from a diseased field, trying to get only healthy plants from this field. The result was, 2,850 germinated in the first case, and only 50 germinated in the second case. One estate in the island took 80,000 plants to supply 77,000 holes. These instances, in our opinion, show one of the effects of planting diseased canes, another effect being, according to Kew experiments, to produce the root form of the disease.

“The careful selection of plants has been urged, not only in Barbados, but in every cane-growing country where disease has led to careful investigation, and the practice of indiscriminate selection of plants has been universally condemned. There can be no doubt that while we have not sufficient evidence to warrant us in ascribing the October rind fungus to this source, it must yet be a very prolific source of all the diseases which occur in the early life of the young cane; it may possibly be the means whereby root fungus is spread, and is certainly a means of propagating the Moth Borer.

“*Change of Varieties of Sugar-canes.*—Has the continual propagation of one variety led to degeneration? There is no evidence upon this point beyond the impression left by a comparison of the Bourbon with other and with seedling varieties. Analogy teaches us that direct propagation from seed is the one most likely to maintain a vigorous species, and that although by propagation from cuttings we may gradually modify a plant to develop richness in some one respect and to maintain some one quality, yet a gradual decrease of general vitality may result, and a want of adaptation to surrounding circumstances. The production of plants from seeds possesses advantages of maintaining vitality, of adaptability to surrounding conditions, and of lending itself to the production of new qualities.

“General experience in other countries shows, on the one hand, that a change of varieties is an effectual way of combating plant diseases. Thus, Mauritius is reported to find a constant change of great value, Queensland is said to have greatly mitigated the ravages of the rust by this method, and lastly, there is an ever-increasing store of evidence of the most reliable kind to show that there are several varieties of cane in Barbados (including some seedling canes) which possess a striking, though not complete, immunity to fungoid attack.

Propagation
from seed.

Change of
varieties
recom-
mended.

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disease.

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"The following biological consideration leads to the same view, that where one variety of plant is cultivated to the practical exclusion of all others, that all the parasites of that plant enjoy the very best conditions for their continuous propagation and increase. Or to reduce this generality to our special case, that continuing to plant the Bourbon cane is to provide a continuous supply of material for the rind fungus to grow and increase upon. Change the variety, and the parasite exists with much greater difficulty or has to change its habits.

"The fact that both the rind fungus and the root fungus are so much less liable to attack certain varieties of the cane other than Bourbon cannot fail to be a fact of immense value.

Hardy
varieties to
be cultivated.

"Your Commission after very careful inquiry not only found that certain varieties of canes strongly withstand both root and rind fungus, but the record also shows that at all events in some places these varieties are very profitable to cultivate, and your Commission most strenuously advocates that the cultivation of these varieties should be extended in every direction, cultivating in each district the variety which proves most fitted for it. During the last few years, the diseases which attack the Bourbon sugar-cane have steadily increased in amount, and the history of like cases points to the belief that this increase will go on and not abate until some very serious measures are adopted; and amongst them we consider the cultivation of new varieties as one of the most promising. With the present prospect as regards price of sugar, the whole industry can only exist by the strictest economy in cultivation and manufacture; and with any serious amount of disease, cultivation must cease to be profitable. Undoubtedly, if the progress of the present disease in Barbados cannot be checked, the island is doomed to ruin. And all considerations point to the conclusion that the whole island must be ready to abandon, if necessary, the cultivation of the Bourbon variety. Your Commission recommends that every estate should be ready by having such an amount of cane varieties planted as will serve to supply, if occasion demands, a sufficiency of plants to plant the whole estate in those varieties."

Bourbon
variety
susceptible.

Mr. W. Scott, of Mauritius, when forwarding in 1893 a case to Kew containing a quantity of sugar-canes, made the following remarks (*Kew Bulletin*, March 1894, p. 81): "The disease, by what I have

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disease.

seen, appears to attack different patches in the field, and although the foliage appears healthy, the body of the cane is attacked near to the nodes with what appears to be a disease of a fungoid nature, indicated on the surface of the cane by red blotches. Where these exist the under-surface of the cane becomes dry and spongy, but does not, as far as I have been able to ascertain as yet, affect the growth of the cane. The main feature of the disease appears to be that it retards the crystallization of the juice to a very marked degree when it reaches the boiler, and even the sugar produced falls short of what might be expected."

GENERAL
DESCRIPTIONDiminution
in sugar.

The following notice taken from the *Demerara Argosy* of 16th November 1895 records the effect of the disease upon the crop in British Guiana: "To add to our distress that has hung like a thick cloud over our sugar industry for several years, the rind-fungus has appeared among the canes and is causing a loss of juice that is variously estimated at from 10 to 20 per cent. A leading planter informs us that the quality of the juice is not affected by the fungus as is the case when canes attacked by the borer are crushed along with good canes; but the quantity is seriously affected, the portion of the cane which the fungus has attacked having nothing left in it but fibre."

British
Guiana.

Loss of juice.

The loss is, perhaps, underestimated in the above case, at any rate the annual deficiency in one estate was 75 per cent. In St. John's, Grenada, on many of the estates, it was computed that it would require five or six acres of canes to make a hogshead, a statement which indicates a remarkably poor yield of sugar when compared with the average outturn which is from two to three hogsheads to an acre.

Estimate
of Loss.

In the Barbados the canes planted in December seem to receive a check in their growth about June or July following. In course of time the plant looks sickly and dwindles, although attempts are made by fresh basal shoots to supply the place of the dying ones. After the lapse of another six months, *i.e.*, in November and December, just as the crop is expected, no cane has been formed, growth having apparently been completely arrested (*Kew Bulletin*, 1893, p. 349).

Growth
arrested.

The disease in many colonies appears to exercise discrimination in its ravages and to select one variety of cane where others are growing in the same field. The Curator of the Botanical station in the Island of Grenada was struck by the fact that in all the diseased

Discrimina-
tion of the
disease.

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disease.

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fields only the Bourbon cane was affected ; the Caledonian Queen, Striped Singapore, and Purple Transparent were at the same time healthy and vigorous.

In the Muzaffarnagar district of the North-West Provinces it was noticed that only one variety of cane, the *merthi*, was attacked ; other varieties growing close by showed no sign of fungoid disease.

It has been expressed, on the other hand, that no variety of cane is immune from the attacks of this fungus provided that the health of the cane is weakened in any way, and that it suffers from insect attack or other mechanical injury to its tissues.

Mr. Harrison, of Demerara (*Kew Bulletin*, May and June 1896, p. 107), partly attributes the appearance of the disease to drought since as long as constant wet seasons prevailed the disease remained unnoticed. This gentleman also observed that it was practically common only on front lands which had been under cultivation for many years, the richer back lands being free from the blight.

REPORT* ON THE SUGAR-CANE DISEASE

BY MR. MASSEE.

MR.
MASSEE'S
REPORT.

" The abundant supply of living material, consisting of 18 large canes, illustrating every stage of the disease, sent to Kew for investigation by Mr. Bovell, from Barbados, has enabled the vexed question as to the part played by fungi in connexion with the sugar-cane disease to be conclusively settled.

* * * * *

" Microscopic examination showed the presence of the fungus in every cane, but in some instances, owing to the absence of fruit, its presence could not be detected by the naked eye.

" Only one fungus—an undescribed species of *Trichosphæria*—was found on the canes. The idea entertained by some planters, that more than one fungus is connected with the disease, probably arises from the fact that the *Trichosphæria* has at least three distinct forms of fruit, very different in general appearance, and whose development depends on the relative vitality of the canes.

" Further experiments showed that *fully developed* leaves and stems cannot be infected on an unbroken surface ; nevertheless, when the

* *Kew Bulletin*, July 1893, p. 150.

surface is broken, infection is readily effected. A cane about $1\frac{1}{2}$ inches diameter was inoculated by cutting a deep slit and introducing mycelium from a pure culture of the conidia; in sixteen days the cane was split at this point, and the central portion was found to be coloured red for a distance of 3 inches, and the mycelium had extended even beyond that distance, the microscope showed the presence of the dark olive conidia formed in tissues away from the light. Infection also readily takes place at points where lateral branches have been broken off.

Summary
of results.

“*Summary*.—1. The experiments described above prove that the *young* leaves of the sugar-cane can be infected by the spores of *Trichosphæria* falling on an unbroken surface, and further, that the fungus acts as a true parasite, eventually killing the plant.

“2. In older plants inoculation can only take place when the surface is wounded, but when an entrance through a wound is once effected the fungus acts as a destructive parasite.

“3. The frequent presence of both fungus and moth-borer or shot-borer in the same cane is explained by the above statement.

Conidial
form.

“*Stage I*.—Conidial condition, for the rapid reproduction of the species; appearing on the surface of wounded parts as a very delicate, dark-coloured velvety mass, or when old and very abundant, penetrating the internal tissue of the cane and producing a black charred appearance, due to the numerous chains of large olive-brown conidia.

Melanconium
form.

“*Stage II*.—Melanconium form, bursting through the cuticle of old canes in the form of minute black filaments. Often following the ravages of the ‘Moth-borer’ or ‘Shot-borer’ in dying or dead canes.

Ascigerous
form.

“*Stage III*.—The ascigerous form. Minute, black, hairy perithecia, present only on dead and more or less decayed portions of cane.

“The conidia from Stage I., obtained from a pure culture, were placed on the unbroken surface of *very young* leaves of lateral shoots of a healthy sugar-cane plant growing in the Lily House, Kew Gardens; in 5 days the infected areas showed deep red blotches, and in 14 days the conidial form of the fungus was perfectly developed, the mycelium in the meantime having passed into the shoot and adjoining leaves. Soon afterwards the young infected

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shoots decayed and dropped off, microscopic examination showing that the mycelium had passed into the tissues of the parent stem.

"Assuming the insect to first pierce the cane, the spores of the fungus would find a suitable place for development in the wound; hence the presence of one parasite prepares the way for another, and the combined action of the two soon ends in the destruction of the plant. Nevertheless the fungus is not entirely dependent on the previous presence of the insect, but readily finds entrance at broken points and can alone kill the cane."

ROOT
DISEASE.**REPORT ON "ROOT DISEASE" OF SUGAR-CANE**

BY MR. MASSEE.

A parasite
fungus.

"The stools of sugar-cane sent to Kew by Mr. Bovell from Barbados for the purport of ascertaining the cause of the "root disease," arrived in excellent condition for that purpose, and an examination of them demonstrates conclusively that the disease is due to a parasite fungus known as *Colletotrichum falcatum*, *Went*. The fungus cannot effect an entrance through the unbroken surface of the stem of the sugar-cane. But the conidia germinate on decaying lateral shoots or the ragged base left by fallen leaves. Its entrance into the living portion is indicated by a bright red colouration of the fibro-vascular bundles, the colour subsequently extending to the ground tissue.

"When an entrance has been effected the hyphæ spread rapidly throughout the length of the cane, and after a time the fructification ruptures the epidermis in the neighbourhood of the joints, and appears on the surface as a more or less effused black, minutely velvety patch.

Microscopic
examination.

"Microscopic examination shows the velvety appearance of the fruiting patches to be due to the presence of numerous rigid, dark-coloured hairs, springing from a dense basal web of colourless hyphæ; these latter also bear large numbers of minute, colourless conidia, or reproductive bodies. The conidia are capable of germinating the moment they are mature, and being produced quickly and readily disseminated, easily infect neighbouring plants.

"A second kind of conidia are formed on the oldest portions of mycelium present in the tissues, two or three large globose conidia

* *Kew Bulletin*, December 1893, p. 347.

Sugar-cane in the West Indies. (G. Massee.)

SUGAR-CANE
disease.MR.
MASSEE'S
REPORT.

being frequently found on the hyphæ present in a single cell of the cane. These internal conidia can only escape when the cane in which they exist has become thoroughly decayed. The fungus, under normal conditions, attacks the above-ground portions of the cane, the "root disease" condition being a modification of the normal form, called into existence by the method of cane cultivation adopted.

"A careful examination of all the canes forwarded shows that the portion buried in the ground contains much more mycelium than that above ground, the mycelium in the root is also more mature, frequently producing enormous quantities of conidia in the cells. In some instances the root was rotten and decayed, the disintegration being effected by the fungus; nevertheless there is not the slightest evidence to favour the idea that the disease originated *after* planting. Many of the small roots contained a large quantity of mycelium, but it was evident in every case that this had passed from the stock into the root. On the other hand, everything points to the conclusion that the portions of cane used for propagation already contain the mycelium of the fungus, although its presence may not be indicated externally, and that the mycelium present in the buried portion of the cane favoured by darkness and moisture, develops at an abnormal rate, thus assuming the character of a disease, which in its intensity is foreign to the fungus when developing under normal conditions. Two additional species of fungi, not in any way connected with the disease, were common on the fading leaves of the canes; the one, a species of *Chætostroma*, the other a *Botrytis*. The last mentioned was also found on canes sent previously by Mr. Bovell, and it was suggested at the time that it might be connected with the disease. But further investigation has not in any way confirmed this; the *Botrytis* may for the future be dismissed from consideration.

The disease
affects root
and stem.

"The sugar-cane disease in Java, called Root Snot* is apparently the same thing, and it would be interesting to ascertain if this is the source from which it has been introduced into the West Indies.

"*Summary.*—The disease is caused by a parasitic fungus called *Colletotrichum falcatum*, Went, and the evidence points to the injudicious use of diseased canes for propagation as the cause of the injury to the crop which is now experienced.

*Colletotri-
chum
falcatum.*

* Het Root Snot : Dr. Went (H. Van Ingen : Soerabaia, 1893).

SUGAR-CANE
disease.

An Account of the Fungal Disease attacking

PREVENTIVE
MEASURES.

PREVENTIVE MEASURES.

Diseased
canes to be
burnt.

1. *All diseased canes should be burnt and not allowed to decay naturally.*—The disease is indicated externally by the appearance of numerous minute upraised points just above the nodes towards the base of the cane; from these points proceed black sticky masses on the surface of the cane; these are the spores of the melanconium stage of the fungus which as soon as they are liberated are dispersed by wind and rain and in turn infect new areas. The matured conidia of this fungus are very abundant in the decayed and dead portions of the canes, hence all such should never be allowed to rot, but should be at once burnt to prevent further extension of the disease.

Healthy
canes to be
used for
propagation.

2. *Perfectly healthy canes should be used for propagation.*—To secure this the canes should be obtained from an area not infected with the disease. The hyphæ of the *Trichosphæria* from the old portion of the cane readily enter the “stools” or young shoots growing from it, and these shoots or tops on no account must be used even if they have an apparently sound appearance.

Rotation of
crops.

3. *The fields attacked should be planted up with other crops.*—This is a very essential point as the litter of cane leaves, etc. on the ground will be infected with the fungus, and perfectly healthy plants would be attacked if planted at once on an infected site. Mr. Bovell has tried this remedy with success.

Fungicides.

4. *The use of fungicides.*—There is a possibility of the cut and exposed surface of the portion used for propagation being inoculated with the fungus spores. As a preventive against this cause of inoculation, the cut surfaces might be painted with a solution of Bordeaux mixture immediately on being cut, and repeated at intervals.

The conidia of the fungus will not germinate, neither will the mycelium grow in a 1 per cent. solution of cupric sulphate; but spraying with the ordinary Bordeaux solution is in all probability not practicable, other than in the case of an experimental plot, and would certainly have no beneficial effect on an infected area.

Nurse plants
to be avoided.

5. *Further precaution.*—It has been observed that the fungus causing the sugar-cane disease develops readily on the young leaves of the bamboo, the same may prove to be true of other members of the GRAMINEÆ, hence a careful search should be made for

(Conf. Massee, Kew Bulletin, 1897, July, p. 151; Dec., p. 348.)

Sugar-cane in the West Indies.

SUGAR-CANE disease.

PREVENTIVE MEASURES.

Recommendations of Barbados Commission.

such possible nurse plants, as the spores would be carried for a considerable distance by the wind.

The "Remedies and Recommendations" with regard to the spread of the sugar-cane disease drawn up by the Commission appointed in Barbados (*Kew Bulletin*, April and May 1895, p. 85) may be also suggestive.

1. That a strong central committee of planters and others who represent the interest of the Island as proprietors and attorneys, and who are favourable to remedial measures, be appointed to see that these measures are carried out.

2. That from this central committee the planters from each parish together with some from the adjoining ones, compose a sub-committee for that parish; the duties of this sub-committee being to keep the parish under a thorough inspection and to see that all measures are continually and thoroughly carried out.

3. That all plants before planting be soaked in Queensland solution * or other solution which the Island Professor of Chemistry, with the approval of the central committee, certifies to be equally efficacious.

4. That wherever deemed possible by the sub-committee the practice of spreading trash around young canes be given up; and that wherever it be resorted to only trash from a field which has been inspected by the sub-committee and declared healthy, or as healthy as possible, be employed.

5. The rotten canes on all fields diseased with rind fungus and "root fungus" should be burnt on the field, or crushed and burned as hereinbefore mentioned. In fields diseased with root fungus the stumps should be dug up, the mould shaken off, and be allowed to dry and be burned or buried.

6. That rotten canes on all fields be regularly burned during the crop. Juicy ones could be first crushed and the megass burned, the juice being boiled.

7. That the trash used as litter be taken from fields which are healthy or as healthy as can be got.

8. That each estate put such an area under the so-called hardy varieties of cane plants as will suffice to re-plant the whole of the estate in those varieties if necessary.

* One pint of carbolic acid to 100 gallons of water.

SUGAR-CANE
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9. That when root fungus has made its appearance, ratooning for the present should be gradually given up.

10. That the cane fields be periodically inspected, with a view to cutting out canes infected with Borer or fungus, which canes should be bagged upon the spot and taken away, crushed and burned.

11. Rotation of crops should be especially resorted to in the case of root fungus.

SUGAR-CANE DISEASE IN INDIA.

OCCURRENCE
in
INDIA.Muzaffarna-
gar, N.-W.
Provinces.

Mr. W. Gollan, Superintendent, Government Botanical Gardens, North-West Provinces, in a letter to the Reporter on Economic Products, dated 7th December 1896, drew attention to the prevalence of the disease in Northern India. He wrote : " I have the honour to advise despatch per train of a parcel containing a sample of sugar-cane from the district of Muzaffarnagar attacked by a disease and should feel obliged if you would have the canes examined and inform me if you can offer any explanation as to its cause.

"The disease declares its presence by the leaves assuming a yellowish hue, and in this early stage, if the canes are examined, slight discolouration of the tissues near some of the joints is found. When the disease has fully developed, nearly the whole of the tissues become suffused with red, then fermentation of the juices follow with the death of the plant.

"The disease has been noticed on a limited scale at Muzaffarnagar for two or three seasons past, but this is the first season it has appeared to such an extent as to call for serious notice. Infected plants are always found in groups or patches, and from this fact I should surmise that the disease is of fungoid origin."

Mr. Gollan, on the 16th January 1897, despatched another supply of the sugar-canes, and in the forwarding letter made the following remarks : " I met Mr. R. D. Kobus who was deputed by the Government of Java to collect sugar-cane in India, and from the description he gave me of the disease 'Sereh' which had proved so disastrous to sugar-cane cultivation in Java, I should say that the samples of cane I am sending you from Muzaffarnagar are attacked by the same fungoid disease.

" So far, only one variety of cane, *viz.*, the kind known as *merthi* in the Muzaffarnagar District, has been attacked ; other varieties growing

Sugar-cane in India.

(A. G. Bourne.)

SUGAR-CANE disease.

close by and under the same treatment as given to the *merthi*, have, up to the present, shown no signs of fungoid disease."

The plants were examined on their arrival and were found to have the red-spotted characters of rind fungus. Mr. Gollan was accordingly referred to the articles on *Trichosphæria Sacchari* published in various numbers of the *Kew Bulletin* during the years 1892 to 1896.

The report by Dr. Bourne on the occurrence of *Trichosphæria Sacchari* in the Godáviri deltas is herewith reproduced. The report was printed by the Government of Madras with G. O. No. 127, 127A. (Revenue), dated 3rd March 1898.

From A. G. Bourne, Esq., F.R.S., *Presidency College, to the Secretary to Government, Revenue Department,--dated 28th February 1898.*

I arrived at Cocanada on Monday 21st, and spent the 22nd to 25th in examining the sugar-cane. I returned by steamer this morning and submit a report at once, as if anything can be done it should be done quickly. I have, in anticipation of the approval of Government, informed the Collector and some members of the Chamber of Commerce that the ryots should be induced by all possible means to root up the old stools, to burn all litter, to examine "tops" before planting and to plant only on land where paddy was last year.

The cutting and crushing is now going on and new planting will begin by the next new moon.

I think it would be desirable if Government were to call for a report as to the extent of the disease in all cane-growing districts. In such an enquiry it would, I think, be sufficient to ask whether any of the canes exhibited red spots or patches *in their flesh*. The ryots would have noticed such at the time of crushing. The damage done in the eastern delta at any rate is very great; from the forward crops which have been crushed, only half the usual yield of jaggery has been obtained; while from many still standing, much less will be obtained.

1. *Introduction.*—My attention was drawn to this matter by letters from the Collector of the district and from Messrs. Wilson & Co. of Madras. Numbers of canes in certain localities were reported to be withering and the evil was generally ascribed to the ravages of some insects.

OCCURRENCE
in
INDIA.

Muzaffarnagar.

DR.
BOURNE'S
REPORT.

Godavari.

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REPORT.

A great variety of insects were sent to me, some perfectly harmless to the canes, others undoubtedly capable of doing damage. I do not propose to deal with these here as the total damage done by them in the gardens I have examined is infinitesimal as compared with that done by a fungoid growth.

This growth produces all the symptoms characteristic of an attack by *Trichosphæria Sacchari*, *Massee*.

Fungal
origin.

This is the fungus which has recently threatened to extinguish the sugar industry in Barbados. Different stages in its life history have been known as the "root fungus," and "rind fungus," respectively. I find both stages present and great damage is being done, and unless some measures to check the progress of the disease are adopted at once, matters will go from bad to worse.

Distribution.

Mr. Maxwell, of Messrs. Wilson & Co., kindly secured me the services of several *gumastas*, and we visited a great number of "gardens"—as the sugar-cane plantations are there called—and interviewed the ryots. All the gardens we examined, among which were several reported to be quite healthy, showed much disease, and now that I have pointed out what the symptoms really are I gather from what I have been told that the disease is pretty widely spread along the whole coast, perhaps, even to Ganjam, and that it is no new thing this year but has been gradually coming on for some years. It is, however, only this year that the results have been sufficiently marked to cause it to have been brought to the notice of the Collector and Chamber of Commerce. It has evidently now taken a thorough hold of this district, and is likely, in my opinion, to be infinitely worse next year unless prompt and concerted measures are taken to check it.

Symptoms.

2. *Symptoms*.—Canes but slightly affected, *i.e.*, only recently attacked, show no external signs of disease, but transverse sections show one or more bright red spots in one or more internodes, and if these are followed up by longitudinal sections, they appear as red streaks which branch at the nodes. It is the fibro-vascular bundles which become coloured. Such slight attacks usually occur somewhere about the middle of the length of the cane. Where the disease is more advanced the colouration extends also to the ground tissue, so that any section shows red patches. Subsequently the central portion of each red patch becomes opaque and white, and acquires a

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(A. G. Bourne.)

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Symptoms.

texture like that of a "woolly" radish, the tissue is in fact dead. Where the disease is still further advanced, portions, first at the nodes and later elsewhere, become black, and at this stage, or before, the leaves at the top wither, and the entire cane dries up. Some of the canes only were attacked when sufficiently young to give time for the disease to run its full course, others were attacked at later stages, and are yielding a certain amount of juice. Wherever the fungus has been growing in the cane for a sufficient length of time small, black, minutely velvety spots are to be found among the sleeping roots which look like warts on the nodes. These spots are groups of myriads of spores ready to be distributed by the wind.

Each garden which I examined showed the disease in all its stages, contained in fact plants which had been attacked at different periods.

Native
methods.

3. *Methods adopted by the ryots which bear upon the spread of the disease.*—The only crop raised in rotation with sugar-cane by most of these ryots is paddy, and it appears to be the general custom to keep a particular plot as a sugar-cane garden for two years to plant paddy in the third year, and then revert to sugar-cane. The sugar-cane crop of the first year is raised by planting "tops." Before the canes are passed through the crushing mill the upper portion with the leaves is cut off; this when trimmed constitutes a "top." The "tops" are put together in a heap loosely covered up with leaves, and are planted out after about four or five weeks, so that they remain exposed to any spores which may be about in the air for a considerable time; during this some of them are doubtless attacked.

Planting of
"tops."

If sufficient "tops" are not available, any joint, *i.e.*, any internode with a couple of nodes showing buds, is used.

The land from which paddy has been recently harvested is ploughed, dry, if possible, after soaking if necessary. The "tops" are laid out in rows, trampled in, and after sprouting has begun furrows are made and irrigation commences. The second-year crop is raised by ratooning, *i.e.*, the stools of the previous crop are left in the ground, and new shoots grow from them. If a second year-crop has been very good, a third-year crop is sometimes attempted in the same way, but this does not appear to be the custom, nor, apart altogether from this disease, do the ryots seem to expect a third-year crop to be

Treatment
of the land.

SUGAR-CANE
disease.

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DR.
BOURNE'S
REPORT.

Precautions.

Canes for
chewing.Diseases
spread by
spores.Nature of
the spores.

a good one; the canes, they say, are likely to be thin and without much juice. The ratooning seems, under ordinary circumstances, to give very good results for one year. I may, however, at once point out that where this disease is present, to attempt a second-year crop by this method is not only absolutely suicidal, but helps to spread the disease. Almost all the second-year crops now being cut are worse than the first-year ones, and the stools which are now being left to sprout are, I find, almost all infected, so that next year's crops grown from them are almost sure to be complete failures. I expect the shoots, infected as they will be from the very first, will soon wither.

In most gardens a certain number of canes are cut from day to day and sold for "chewing," and fetch about 2 pies each at the garden. The "chewing" season lasts from about January to March. When the bulk of the canes is ripe a mill is erected in nearly every garden, the cutting commences in earnest, and the crushing goes on day and night, on some gardens at any rate. About ten coolies and six pairs of buffaloes are employed at each mill. The leaves are given to the buffaloes, the "tops" are put aside as described above, the crushed stems are spread out upon the ground to dry, and when dry are used as fuel for the boiling which takes place on the spot. The ash and scum are used as manure, and any fuel unused is stacked. At all the mills I visited the procedure was identical.

4. *The way in which the disease is spread.*—This disease is actually caused by the fungus. Insects may damage some of the canes, the quality of the water, the use of unsuitable manure, or the exhaustion of the soil may cause a weak crop; but it must be clearly understood that, if spores of this fungus enter its tissues, the strongest and healthiest cane will be attacked. It is the spread of the spores of the fungus which we must endeavour to check, and unless this is done, no other measures are likely to have any beneficial result.

The spores are extremely minute, and occur in inconceivable numbers in the little black patches on the surface as well as inside the tissues of every diseased cane. They are capable of being dried up without losing their vitality, and in this condition are blown about by the wind. There is no doubt but that in an infected area spores are constantly settling everywhere in the form of impalpable dust

(Vegetable Product Series, No. 44.)

(Dyes and Tans.)

THE AGRICULTURAL LEDGER.

1898—No. 16.

FLEMINGIA CONGESTA.

(THE WARAS DYE.)

[*Dictionary of Economic Products*, Vol. III., F. 633-42.]

THE ARABIAN DRUG WARAS OR WARS.

A Description of its History, Uses and Composition, with Remarks on its Occurrence in India. By THE OFFICIATING EDITOR.

This number of *The Agricultural Ledger* deals with the history and properties of the Arabian drug *Waras*, and the discovery of a similar substance on species of **Flemingia** growing in India. The report by Mr. A. G. Perkin, of the Research Laboratory of the Dyeing Department, Yorkshire College, Leeds, shows that the indigenous product is superior to *Kaméla* (**Mallotus philippinensis**) in imparting an orange colour to silk fabrics. All the available information on *Waras* is reproduced, for the sake of convenience, in the form of a revision of the article in the *Dictionary of Economic Products*.

INTRODUC-
TORY.

Flemingia congesta, Roxb. *Fl. Br. Ind.*, II., 228; *Wight Ic.*, t. 390; LEGUMINOSÆ.

Vern.—*Bara-salpan*, *bhalia*, *supla cusunt*, HIND; *Bara-salpan*, *bhalia*, BENG.; *Buru ekasira nari*, *bir but*, SANTAL; *Batwasi*, NEPAL; *Mipit muk*, LEPCHA; *Dangshukop*, MICH; *Dowdowlá*, BOMB. and MAR.; *Tha kya nai*, BURM.

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FLEMINIGA
congesta.

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References.—Roxb., *Fl. Ind.*, Ed. C.B.C., 572; Gamble, *List of Trees, Shrubs, etc., of Darjeeling*, 28; Dalz. & Gibs., *Bomb. Fl.*, 75; *Science Papers*, 73; Rev. A. Campbell, *Report on Econ. Prod.*, Chutia Nagpur, No. 8465; Atkinson, *Econ. Prod.*, N.-W. P., Pt. V., 94; Kew Report, 1881, 50; Kew, *Off. Guide to Mus.*, 45; *Report Bot. Gard. Nilgiris*, 1884-85; *Pharmacog.*, 573; *Mat. Med.*, W. Ind., 708; *Pharmacog. Ind.*, I., 420; *Pharm. Journ.*, XII. (1853), 589 (Hanbury); [2] IX. (1867), 279, (Flückiger); [3] XIV. (1884), 897 (Kirkby); [3] XIV. (1884), 917 and 969 (Thiselton Dyer); [3] XVII. (1887) 1029, and XVIII. 110 (Flückiger); [3] XVIII. (1887), 213 (Hooper); *Journ. Chem. Soc.*, Aug. 1898., 660 (Perkin).

HISTORY.

History.—Dr. Roxburgh about a century ago called attention to the fact that certain plants belonging to the genus *Flemingia* possessed on the surface of their pods a number of red-coloured glands. In his "Flora Indica" he remarks, that *F. procumbens*, a native of the mountains north of Oudh and Rohilkhand, had its legumes and calyx besprinkled with garnet-coloured grains, and that *F. nana* found in the vicinity of the Ganges towards Hurdwar, had its legumes densely enveloped with clammy reddish powder.

Plants
yielding
glands.

In Burma the pods of *F. prostrata* of Roxburgh have been found to be densely covered with purplish black resinous dots, and Kurz in "Forest Flora of British Burma," alludes to the presence of black resinous dots when describing the legumes of *F. sericans* (*F. Wallichii*, W. and A.), *F. lineata*, Roxb., and *F. ferruginea*, Grah.

In the "Flora of British India" Mr. J. G. Baker has reduced all the above-named plants with the exception of *F. Wallichii* and *F. lineata* to one species, viz., *F. congesta*; and *F. Grahamiana*, W. and A., a Nilgiri and Burmese plant, also affording red viscous glands, is not far removed from it specifically.

Kamela.

The only other glandular product that bears any resemblance to that found on the pods of these leguminous shrubs is the red-coloured powder known as *Kamela* which is obtained from the capsules of a Euphorbiaceous tree, *Mallotus philippinensis*.

Kamela is a well-established dye in India and its botanical origin has been long known, but it is only within the last few years that Waras, an equally ancient drug, has been referred to a species of *F. 633-42*.

The Arabian Drug Waras or Wars.

(D. Hooper.)

FLEMINGIA
congesta.

Flemingia growing in the East. The history of this discovery is of great interest in showing the difficulties experienced in tracing the source of products which lie outside the beaten tracts of European commerce.

HISTORY.

Arabian
accounts.

Arabian physicians as early as the tenth century mention this drug under the name of *Kanbil* or *Wars*. Ibn Khurdadbah, an Arab traveller living A.D. 869-885, states that "from Yemen came striped silks, ambergris, *wars* and gum." Kaswini in the thirteenth century was also acquainted with wars which he says was a plant sown in Yemen and resembling sesamum. Constantinus Africanus likewise spoke of *huars*. It should be remembered that Wars, Wors, Wurrus or Warras in Arabic are, properly speaking, terms signifying saffron, the origin, among a few other plants, of the auspicious yellow dyes of Eastern countries.

These earlier Arabian writers appear to have confounded the drug *kamala* or *kinbil* (the Sanskrit name converted into an Arabic form) with the waras produced in Arabia and Ethiopia. The red kinbil or waras mentioned by them was probably all imported from India as we have no evidence that *Mallotus philippinensis* grows in Arabia and North-East Africa.

Later
authorities
quoted.

In later writings these two drugs are more particularly distinguished, and an Abyssinian variety is described as being black and an Indian which is red. The author of the "Kamus" who wrote about A.H. 768, notices both kinbil and waras, and treats them as two distinct substances. He says of kinbil that it is red and astringent and that it kills and expels intestinal worms and cures scabby affections of the skin. Of waras he says the plant is like sesame and only found in Arabia; externally applied, it removes freckles; taken internally it cures leprous eruptions, but not a word is mentioned about anthelmintic properties. The author of "Makhzan" speaking of waras says there is a black kind, which comes from Ethiopia and it is called *habshi*, and a dull red kind, which is called Indian and is the worst as a dye; he concludes by remarking that the seeds of the waras are like *Mash* (*Phaseolus Mungo*, var. *radiatus*). It is described as aphrodisiac, lithontriptic and a remedy for ringworm, pityriasis and freckles.

The two drugs began to attract attention in England in 1853, when Dr. James Vaughan, Fort Surgeon at Aden, published

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HISTORY.

his notes upon the drugs observed at Aden and other places in Arabia.

The following extract refers to the products under discussion :—

Dr.
Vaughan's
Notes.

“ *Wurrus* or *Waras*, a red powder used chiefly as a dye, is the produce of a plant resembling sesame. I am informed that the plant rises to about five feet in height, bearing several separate bunches or clusters of small round seeds, which are covered with a description of pollen or flower; this removed from the seed-clusters by gentle rubbing or shaking, constitutes the dye; the seeds are afterwards thrown away. Two kinds of *Wurrus* are brought into the market. The best comes from the interior, principally from the towns of O Badan and Gebla and the districts of Yaffae and Sjibul Rudfan. A second kind brought by the Somalis of the opposite coast, comes from the neighbourhood of Hurrer; this is not so much valued and does not realize the price of the other sort. A considerable quantity of the dye I find is exported to Bombay; it is used principally by the people of Surat for the purpose of imparting a light brown yellow colour to their silks, which are much prized and worn by the Native ladies. I believe that *Wurrus* is used for silks only and not for cotton or woollen stuffs. Besides being employed by the Arabs of this part as a dye, the colour produced being highly esteemed, they use it likewise as an internal medicine in cases of leprosy, and externally in solution as a lotion to remove freckles and pustules. Much of this dye finds its way to the Persian Gulf, where it is known under the name of *Asberg*. *Wurrus* sells in Aden for about twenty-four rupees the maund, but the African or inferior description realizes only from seventeen to eighteen rupees the maund.”

Mr. D. Hanbury remarks that the *Wurrus* of which two samples had been received from Mr. Vaughan consisted of a dull red, granular, sand-like powder, mixed with small fragments of stalk and leaves, and presumed that it was the *wars* of Niebuhr, which he speaks of as “herbe qui teint en jaune et dont on transporte quantité de Mocha dans l’Omân” (see “Description d’Arabie,” Amsterdam et Utrecht, 1774, p. 133).

Identifica-
tion of
Wurrus.

Mr. Hanbury carefully examined this powder and assigned to it its proper position in the vegetable kingdom in a paper subsequently read that year on “*Wurrus*, a dye produced by *Rottlera tinctoria*.” The latter name of the plant given by Roxburgh is now changed by botanists to that of *Mallotus philippinensis* of *Mueller Argoviensi*. The glandular powder called kamala was made official in the British Pharmacopœia of 1867, but its use as a medicine has

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congesta.

gradually declined, and it has been omitted from the recently published Pharmacopœia of 1898.

Many conjectures were made as to the source of the second kind of kamala or waras and Dr. Sprengel suggested that it was obtained from **Memecylon tinctorium**, (*M. edule*, *Roxb.*,) the leaves of which are used in India for dyeing silk. No glands, however, have been found upon any part of this shrub. The Asberg alluded to in Mr. Vaughan's note as being sold in the Persian Gulf ports is now considered to be the drug known under the various synonyms *Asperag*, *Tráyamán*, and *Zalil*. This consists of the dried herb **Delphinium Zalil** of Aitchison and Hemsley, growing in the moister localities of the Badghis and Khorasan, and exported from Persia as a yellow dye.

In 1867 an authentic supply of waras was imported from Aden by Messrs. Allen and Hanbury, London. It arrived neatly packed in oblong, white calico bags of three sizes each inscribed with Arabic characters, indicating the name of the vendor or collector, a native of Hurrur, a town in Eastern Africa which is a great trading station between the Galla countries and Barbera; the net weight was either 100, 50 or 25 Turkish ounces. No more than two supplies, in all 136lb, could be obtained.

The drug was submitted to a microscopical examination by Professor F. A. Fluckiger, of Strasburg, who noticed that it was in coarser particles than kaméla, it had a deep purple colour and a distinctly peculiar odour. It had evidently been carefully collected and was free from earthy admixture, yet it left upon incineration 12 per cent. of ash. It blackened at a temperature of 100° C., losing 5.2 per cent. of water; kaméla under such circumstances undergoes no change of colour.

Under the microscope waras presented still greater differences, the grains being cylindrical or sub-conical, 170 to 200 mm. long by 70 to 100 mm. broad, and therefore much larger than kaméla glands. The grains are furnished with oblong resin cells arranged perpendicularly in three or four storeys or stages, containing about twenty cells in each stage, very dissimilar to the radiate arrangement seen in ordinary kaméla. The grains were mixed with a few long colourless, transparent, simple hairs, not stellate or tufted as in the allied drug.

HISTORY.

Confused
with other
dyes.

Imported
from Aden.

Professor
Fluckiger's
examination.

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HISTORY.

A.—Gland of *Flemingia* pods.

a.—Simple hairs of ditto.

B.—Gland of *Mallotus philippinensis*.

b.—Tufted hairs of ditto.

Description
of waras.

The above illustrations are reproduced from those given by Professor Fluckiger in his paper written in 1867, on "A New Kind of Kamala." It is at once seen that, apart from the dissimilar structure as observed under the microscope, it differs from the *Mallotus* glands in the larger size and deeper colour of the grains.

A Swiss firm in Aden sent to Professor Schaer, in 1878, a powder under the name of *Vars* which was identified with the above. It was said to be used chiefly in the coast districts of Muscat (Oman) and Hadramaut, in skin diseases and as a dye.

Efforts were made in different quarters to ascertain the botanical source of the purplish-red powder. At the suggestion of Professor Fluckiger, Major Hunter, the Assistant Resident at Aden, kindly interested himself in the matter and succeeded in obtaining specimens of the plant said to yield the Arabian waras. A dried plant was also sent to Kew with a note stating that it was gathered at an elevation of 6,000 feet on Jebel Dthubarah, 60 miles due north of Aden. The plant was immediately identified with the leguminous

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The Arabian Drug Waras or Wars.

(D. Hooper.)

FLEMINGIA
congesta.

HISTORY.

Major
Hunter's
Notes.

shrub **Flemingia congesta**, *Roxb.*, and the fact was announced in the "Kew Report" for 1880.

The following interesting Notes on the collection of the dye at Harrar were contributed by Major Hunter, and published by Mr. W. T. Thiselton Dyer, C.M.G., C.I.E., F.R.S., Director of the Royal Gardens, Kew:—

"In the neighbourhood of the city 'wars' is not now raised from seed sown artificially, and it is left to nature to propagate the shrub in the surrounding terraced gardens. The plant springs up, among jowari (**Andropogon Sorghum**), coffee, etc., in bushes scattered about at intervals of several yards more or less. When sown, as among the Gallas, it is planted before the rains in March. If the soil be fairly good a bush bears in about a year. After the berries (pods) have been plucked the shrub is cut down to within six inches of the ground. It springs up again after rain and bears a second time in about six months, and this process is repeated every second year until the tree dies. Rain destroys the berry (pod) for commercial purposes; it is, therefore, only gathered in the dry season ending about the middle of March. The bush grows to a maximum height of six feet, and it branches close to the ground. The growth is open and the foliage sparse. Each owner has a few acres of land.

"In the middle of February, 1884, the following processes were observed:—

"The leaves [? fruiting shoots] of some plants were plucked and allowed to dry in the sun for three or four days. (The picking is not done carefully and a considerable quantity of the surrounding twigs, etc., is mixed with the berries [pods]). The collected mass was placed on a skin heaped up to about six or eight inches high and was tapped gently with a short stick about half an inch thick. After some time the pods were denuded of their outer covering of red powder which fell through the mass on to the skin. The upper portion of the heap was then cleared away and the residual reddish-green powder was placed in a flat woven grass dish with a sloping rim of about an inch high. This receptacle was agitated gently and occasionally tapped with the fingers, the result being the subsidence of the red powder and the rising to the surface of the chaffy refuse which latter was carefully worked aside to the edge of the dish and

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FLEMINGIA
congesta.

The Arabian Drug Waras or Wars.

HISTORY.

then removed by hand. This winnowing was continued until little remained but red powder. (No great pains are even taken to eliminate *all* foreign matter.) A *roll* was sold in 1884 for about 13 piastres = 1 rupee 10 annas nearly.

Uses.

“ ‘ Wars ’ is sent to Arabia, chiefly to Yemen and Hadhramaut, where it is used as a dye, a cosmetic and a specific against cold. In order to use it, a small portion of the powder is placed in one palm and moistened with water, the hands are then rubbed smartly together, producing a lather of a bright gamboge colour, which is applied as required.”

Botanical
source.

Subsequent consignments of the waras plant from Aden, through the assistance of Major Hunter, were forwarded to Kew and they were found to bear a close resemblance to **F. rhodocarpa**, *Baker*, a plant discovered previously at Mozambique and characterised by having its pods covered with a bright-red, resinous pubescence. A sample of Somali waras received in 1883 was mixed with seeds of a dull brown colour mottled with black ; this description applies to the seeds of **F. rhodocarpa**, and a further scrutiny led to the conclusion that this or an allied species was the origin of waras. Professor Oliver subsequently discovered that **F. Grahamiana**, apparently confined to South India was not specifically distinguishable from the African plant **F. rhodocarpa**, as the pods were clothed with the same peculiar epidermal glands.

Discovery
on the
Nilgiris.

Mr. M. A. Lawson, about this time (1883), was appointed Government Botanist of Madras and Director of the Cinchona Plantations, Nilgiris, and he was invited by Mr. Thiselton Dyer, to examine the **Flemingias** in the neighbourhood with the object of more particularly investigating the epidermal glands said to be attached to the pods. Mr. Lawson succeeded in collecting several ounces of the powder which was the produce of **F. Grahamiana** and **F. congesta**.

F. Graham-
iana.**F. congesta.**

“ With respect to the distinctive characters of these two species,” he wrote in the annual report, “ I pointed out that after studying the plants in their living condition, I did not think them sufficiently constant to allow of the two species being kept separate, and in this opinion both Mr. Thiselton Dyer and Professor Oliver now concur. **F. congesta** is the hill form growing on more or less exposed places, while **F. Grahamiana** grows at lower elevations and in woods.”

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The Arabian Drug Waras or Wars.

(D. Hooper.)

**FLEMINGIA
congesta.**

Through the kind offices of Dr. D. Prain, I have been permitted to examine all the Indian *flemingias* preserved in the Herbarium of the Royal Botanic Garden, Sibpur. The pods of a goodly number of the forms were observed to yield more or less the glandular powder, but it was particularly evident on *F. Grahamiana*, *Wight*, *F. congesta* var. *Wightiana* (*F. Wightiana*, *Benth.*) and *F. Wallichii*, *W. & A.* Dr. Prain considers the *Grahamiana* species to be quite distinct from *F. congesta*. All the mounted plants of this genus whether they afforded the glands or not were capable of staining the paper on which they were fixed an orange-yellow colour, owing to the employment of alcoholic solution of corrosive sublimate in poisoning them.

On the Nilgiris the fruits ripen in the cold weather during December and January when they are covered with the peculiar red glands. The drug is collected by cutting off the clusters of pods from the ends of the branches and placing them in the sun to dry for one or two days. They should be placed on boards or paper, as during the process of drying much of the powder falls, and would be lost unless such a precaution were taken. The pods are then pressed or rubbed together by hand over sieves. The powder will be found to be mixed with hairs, stones and pieces of stalk; from these impurities it is readily removed by finally passing it through a fine muslin or lawn sieve.

Although the plants occur pretty frequently in India very little seems to be known by the natives of their colouring or medicinal properties, and from enquiries made of local traders, no information could be gleaned of the powder being a marketable article. At an exhibition of the Agri-Horticultural Society of Madras held a few years ago, some of the powder was said to be shown by a native dyer, but this has not been observed since, and kamela is the usual vegetable dye used for colouring silk in Madras.

Rev. A. Campbell, in a report on the economic products of Chutia Nagpur, writes of *F. congesta*:—"The pods are said to yield a dye." It would thus appear that the Santals are to some extent familiar with the nature of the shrub.

The plants are not sought after by the natives as they appear to have very little virtue either in medicine or food. Atkinson reports that the pods are occasionally eaten in the North-West Provinces,

HISTORY.**Collection.**

Waras not
a trade
article.

Known by
Santals.

Further
uses of the
plant.

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congesta.

The Arabian Drug Waras or Wars.

HISTORY.

and Rev. Mr. Campbell informs us that the roots are employed by the Santals as an external application to ulcers and swellings, mainly of the neck.

F. tuberosa.

Flemingia tuberosa, Dalz., a native of the Konkan, affords tuberous roots which are eaten either raw or roasted, and are considered medicinal. **F. vestita**, Benth., of Assam, yields a tuber known as *Sophlang*, which is grown as a crop similar to the potato. It is interesting to notice that the leaves of these two plants are studded with minute golden glands which consist of a pigmental resin.

CHEMICAL
COMPOSITION.

Chemical Composition.—The resinous colouring matter which constitutes the chief part of waras has a brittle consistence; it is of a deep garnet-red colour in bulk and orange-red when observed in thin strata. It is soluble in ether, alcohol, chloroform, acetic acid, and in solutions of potash, soda and ammonia and the alkaline carbonates. Sulphuric acid dissolves it in the cold. Heated with nitric acid it rapidly oxidises, yielding yellow-coloured products and a resin soluble in alcohol. Heated with potash or soda an odour of citron is evolved. An ethereal solution of the resin allowed to evaporate spontaneously deposits a mass of crystals. The crystals are lighter in colour than the surrounding red resin, and examined microscopically, they appeared as crops of acicular prisms radiating from a common centre. The name “flemingin” was suggested for these crystals when the writer analysed the drug in 1887.

Besides the resinous and crystalline principles of waras, there are albuminous and saccharine matters soluble in water, an amount of ash varying between 5 and 12 per cent., and a trace of volatile oil. The following results of an approximate analysis of waras made by the writer are reproduced, together with an analysis of kaméla made by Dr. Thomas Anderson, of Glasgow, in 1855 :—

Proximate
analysis.

	Waras.	Kamela.
Resinous colouring matters	72·83	78·19
Albuminous matter, etc.	8·20	7·34
Cellulose	9·50	7·14
Water	3·44	3·49
Ash (principally sand)	6·03	3·84
Volatile oil	trace	trace
	<hr/> 100·00	<hr/> 100·00

Mr. Perkin's
analysis.

A chemical examination of waras has very recently been made by Mr. Arthur George Perkin, F.R.S.E., whose invaluable researches in the natural colouring matters of India are well known. The F. 633-42.

The Arabian Drug Waras or Wars.

(D. Hooper.)

FLEMINGIA congesta.

CHEMICAL
COMPOSITION.

results of the investigation were communicated to the Chemical Society of London in a paper entitled "Constituents of the Indian Dye-stuff Waras, *Flemingia congesta*" (*Journ. Chem. Soc.*, Aug. 1898). At the instance of the authorities at the Imperial Institute the sample consisting of a few ounces of the powder had been collected at Naduvatam, on the Nilgiri Hills, and was forwarded to London through the Reporter on Economic Products to the Government of India.

The analysis resulted in the isolation of the following constituents:—

Flemingin $C_{12}H_{12}O_4$, is a dull orange-red crystalline powder, consisting of small prismatic needles melting at $171-172^{\circ}$. In appearance and numerous properties it resembles the rottlerin of kamala, but is distinguished from this by its solubility in alcohol and acetic acid, and by the browner tint of its alkaline solutions. In an alkaline bath, it dyes silk a golden yellow and is a stronger dye-stuff than rottlerin. On fusion with alkali it gave acetic acid, salicylic acid and an acid of higher melting point which was not identified.

Flemingin.

Homoflemingin ($C=69.97$; $H=5.75$), a yellow colouring matter, present only in minute quantity, forms glistening yellow needles, melts at $164-166^{\circ}$, and possesses properties resembling those of flemingin.

Homoflemingin.

Resin of high melting point, $C_{12}H_{12}O_3$, forms a brick-red powder soluble in alkali with a deep brown tint and yields acetic and salicylic acid on fusion with alkali. It dyes silk in shades which are redder than those produced by flemingin.

Resins.

Resin of low melting points $C_{13}H_{14}O_3$, is a deep orange-brown transparent mass which melts below 100° , is soluble in alkali with an orange brown colour and closely resembles the resin of low melting point of kamala. On fusion with alkali, acetic and salicylic acids are obtained, and on boiling with nitric acid (sp. gr. 1.5) oxalic acid is formed.

Mr. Perkin summarises the results of the examination in the following terms:—"This investigation indicates that waras contains five distinct substances, namely, flemingin, homoflemingin, resins of high and low melting points, and a wax. Although these are not identical with any constituent of kamala, the analogy between these

Summary.

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**FLEMINGIA
congesta.****The Arabian Drug Waras or Wars.****CHEMICAL
COMPOSITION.**

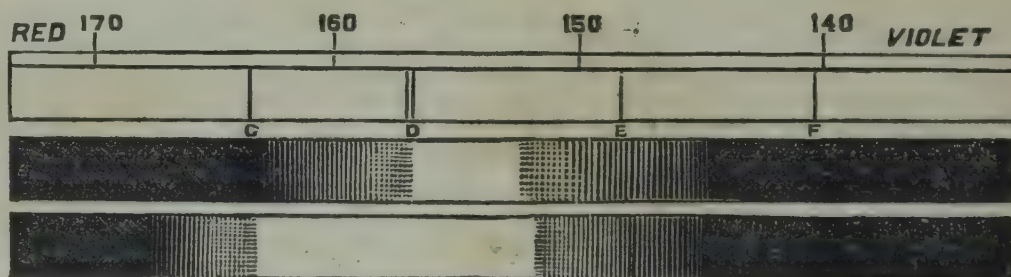
drugs is remarkable, for from the latter rottlerin, homorottlerin, a high and low melting resin and a wax can be isolated. The products from both sources, moreover, have many special characteristics in common, and there can be but little doubt that a close chemical relationship exists between them. The kamala substances contain, as I have previously pointed out, a cinnamyl nucleus, and thus, by decomposition with alkali, give benzoic and acetic acids; those from waras, on the other hand, yield in the same way salicylic and acetic acids, which suggests they may contain a hydroxycinnamyl group."

**PHYSICAL
PROPERTIES.**

Spectrum of Waras.—The physical properties of the colouring substances were examined by preparing separate tinctures of waras and kamela, and observing each by means of a spectroscope.

Spectrum.

The tincture of waras had a deeper red colour than that of kamela and was mixed with more spirit to make the two tinctures resemble each other in tint. Notwithstanding the dilution, the spectrum of waras showed more absorption than the kamela. There was complete absorption at both ends of the spectrum, and no darkness in either case at the Fraunhofer line D. The only difference of note was that the soluble constituents of kamela were transparent to a light of somewhat greater wave length than waras. No absorption bands were visible in either spectrum. The accompanying illustration shows the peculiarities of the spectra of the two pigments. It is reproduced from an article printed in the *Proceedings of the Royal Society of Edinburgh* for 1890 on "The absorption spectra of certain vegetable colouring matters," contributed by Prof. C. Michie Smith, of Madras.

Waras.**Kamela.****DYEING
PROPERTIES.**

Dyeing Properties.—Waras like kamela is an excellent dye for silk, but is not suitable for linen or cotton. Mr. (now Sir Thomas) Wardle, of Leek, undertook in 1884 to examine the dyeing properties of waras, a sample of which had been collected by Mr. Lawson on the Nilgiris. Mr. Wardle reported that the substance

The Arabian Drug Waras or Wars.

(D. Hooper.)

FLEMINGIA congesta.

DYEING PROPERTIES.

contained a small amount of colouring matter compared with the vegetable yellow dyes of commerce and no colour could be obtained from it which would compare in depth and richness with those produced by kamela. Waras also appeared to be inferior to kamela in permanence as regards the action of light. The colour of waras was noticed to easily turn brown by alkaline solutions, whilst kamela is only slightly reddened. Both dyes, however, resist the action of acids very well. Waras was tried on cotton with and without mordants, and the result was a pale shade of yellow.

Mr. Perkin offers the following remarks as the result of his experiments with this pigment:—"Suspended in a boiling solution of its own weight of sodium carbonate, waras readily dyes silk golden yellow shades, very similar to those produced by kamela, but slightly duller and more orange. Material was not available for extended study of its tinctorial properties, but it was at once evident that, in strength, waras is a decidedly superior dye-stuff to kamela. Whether it is capable of competition with the yellow dye-stuffs of commerce cannot be determined until larger quantities can be procured for more extended work in this direction. In the meantime, I shall be grateful for information which will enable me to obtain a supply of this material."

Superior to Kamela.

The opinions of the two experts are somewhat divergent considering the fact that the samples had been gathered from similar plants growing in the same district of South India. The powder used by Mr. Wardle was slightly mouldy and had been damaged owing to the excessive wetness of the season; on the other hand, the specimen sent to Mr. Perkin had been procured in the dry weather and was despatched without delay in a stoppered bottle.

Divergent opinions.

The larger proportion of resinous colouring matter in the waras, the richness of its solutions, and the absorptive power observed in a spectrum, indicate its superiority over kamela, and confirm Mr. Perkin's conclusions.

Notwithstanding the wide distribution of **Flemingia** plants in India the glandular hairs peculiar to some species are at present not much more than a botanical curiosity. Now that attention has been drawn to the Arabian trade in an identical substance and to the delicacy of the dye from an indigenous source, it is hoped that those in a position to do so may be induced to search for the powder and endeavour to make it a commercial article.

Further information required.

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(Vegetable Product Series, No. 45.)
(Food Substances.)

THE
AGRICULTURAL LEDGER.

1898—No. 19.

INDIGOFERA SP.

(WILD INDIGO.)

[*Dictionary of Economic Products, Vol. IV., I. 121-36.*]

WILD INDIGO SEED AS A FAMINE FOOD

IN BOMBAY AND BERAR.

*Report on the Results of Examination of the Seeds at the Research Department,
Imperial Institute. By PROFESSOR A. H. CHURCH, M.A., F.R.S.*

The fact that the grain afforded by certain species of **Indigofera** is eaten in years of scarcity is not new. The grains were largely consumed during the Deccan famine of 1877-78, and were described in a paper read by Dr. W. Gray before the Bombay Medical and Physical Society in 1882. The seeds were ground to flour and either alone or mixed with cereals they were made into cakes which were very palatable. They were occasionally eaten in a raw state when ill-effects supervened, but in all cases when properly prepared and cooked they afforded a nourishing food which had all the characters of pulse.

From a letter addressed early this year to the Survey Commissioner and Director, Land Records and Agriculture, Bombay, and kindly communicated by him to the Reporter on Economic Products, it appears that during 1897, a year of great scarcity in India, a considerable number of the people of Malsiras and Pandharpur in the Bombay Presidency, were subsisting on these grains.

Seeds used
for food in
1877-78.

Preparation.

Origin of
present
inquiry.

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INDIGOFERA SP.

Wild Indigo Seed as a Famine Food

BOMBAY.
REVIEW OF
CORRESPONDENCE.

The Survey Commissioner in drawing attention to the subject (letter No. a-353, dated 5th February 1898) forwarded small samples of the grain mentioned. These proved to have been correctly described by the Commissioner as *Indigofera cordifolia*, *I. glandulosa*, and *I. linifolia*. A second supply consisting of 5lb of the seeds of each plant was subsequently received from the Survey Commissioner.

The Reporter pointed out that if it was intended that the grains should be chemically investigated by Professor A. H. Church, a supply of 8 or 10lb of each kind would be required. The additional quantity would allow of a duplicate specimen being placed in the Indian Section of the Imperial Institute.

The Survey Commissioner in replying to this request, drew attention to the fact that the grains had already been analysed by Professor Lyon, Chemical Examiner of Bombay, and enclosed a copy of analysis of these and other seeds made in 1882. The Reporter explained that "the further samples now desired are intended to be sent to the Imperial Institute, London, where Professor Church is conducting an examination of Indian Food Grains on a special plan of his own in which he brings out very prominently the nutrient ratio for comparative purposes." In compliance with this request the Survey Commissioner kindly promised to collect and send samples of the wild grains in question after the monsoon when they would be available.

Samples of the seeds mentioned above were forwarded to the Secretary and Curator, Indian Section, Imperial Institute, in the month of March 1898. At the same time 1lb of each kind of seed was sent to the Royal Gardens, Kew, for exhibition in the Economic Museum.

It is a strange coincidence that on the 25th March 1898, Sir F. A. Abel wrote to the Reporter and drew his attention to these very seeds, stating that Professor Church considered the *Indigoferas* worthy of attention, and hoped it would be possible to send specimens for analysis.

It was evidently found practicable to investigate the grains with the material sent to the Imperial Institute in March, since Sir F. A. Abel wrote on 7th October 1898, F. S. S. 154, enclosing a Report by Professor A. H. Church on the three Indian Food-stuffs under reference.

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Conf. pp. 3,
5, 6.

Reg. Nos.
10338
10337
10336.

in Bombay and Berar. (A. H. Church.) INDIGOFERA SP.

Prefixed to each section of the Report is given certain information furnished through the Survey Commissioner and Director, Land Records and Agriculture, Bombay, regarding the manner in which the grains are prepared for food.

The analysis by Professor Lyon, referred to in the foregoing review, is also given for the purpose of comparison.

Indigofera cordifolia, Heyne.

Vernacular.—*Vekriavas* (Marwara), RAJ.; *Godadi Bodaga, Botsaka*, BOMB.

The mode of preparing the grain of **Indigofera cordifolia** (vern. *Bochka*) for food is the same as that followed in the case of **Indigofera glandulosa**. Of the three **Indigoferas** herein described, this one is stated to be consumed the least.

Professor Lyon's analysis as quoted at page 891 of Dr. Dymock's *Vegetable Materia Medica of Western India*, second edition, is as follows:—

CHEMICAL
COMPOSITION.

Conf. p. 4.

Analysis by
Professor
Lyon.

	Average cereal.	Average pulse.	Indigofera cordifolia.
Water	11'62	10 00	5'28
Fat	3'00	3'50	5'83
Albuminates *	9'12	25'06	35'21
Carbo-hydrates	71'26	51'30	29'34
Cellulose	3'00	7'14	18'90
Ash	2'00	3'00	5'44
* Containing nitrogen (per cent.)	1'46	4'01	5'68
Nitrogen (grains per oz.)	6'38	17'86	24'85
Nutritive carbon (grains per oz.)	170'00	170'00	141'00
Percentage of nutritive value as compared with—			
Average cereal	100'00	...	...
Average pulse . . . . .	...	100'00	83'00

INDIGOFERA SP.

Wild Indigo Seed as a Famine Food

CHEMICAL
COMPOSITION.Reg. No.
10338.*Report on the Results of Examination of Seeds of Indigofera cordifolia, by PROFESSOR A. H. CHURCH, M.A., F.R.S.*

The seeds of this wild indigo are eaten in times of scarcity and famine. They are very small, 100 weighing less than one grain. When suddenly heated they 'pop' like maize. On analysis these percentages were obtained:—

Water	6.1
Albuminoids (from total nitrogen)	30.8
Soluble carbo-hydrates (by difference)	46.0
Oil	1.3
Fibre	11.2
Ash	4.6

The nutrient-ratio is here 1 : 1.6 and the nutrient-value 79. The percentage of albuminoids by the phenol method was identical with the above-given figure.

Indigofera glandulosa, Willd.

Vernacular.—*Vékhariyo*, MAR.; *Barbed*, SHOLAPUR; *Gavachamalandi*, *Kaladgi*, BOMB.; *Vékhariyo*, *Baragadam*, *Barapatálu*, *Boomidapu*, TEL.

Bombay:

Mode of
preparing
for food.

Conf. p. 6.

In preparing *Indigofera glandulosa* (vern. *Badbade*) for food in Bombay the grain is first pounded, then ground like *Bajri* and made into bread. The taste of this bread is somewhat bitter. It is, therefore, made and eaten in the same manner as *Indigofera linifolia* (vern. *Pandharphali*).

Berar:

Seeds
ground and
eaten.Plant used
for fodder.

The seed is also eaten in the Hyderabad Assigned Districts. Under instructions from the Conservator, H. A. D., the Divisional Forest Officer of Buldana District forwarded in April last 10 seers of the grain and reported as follows: "This grain grows wild all over the District in the waste fields. The seed was largely used during the famine of 1897 for grinding into flour, and the plants themselves for camel fodder. I can supply 100 seers of the seed if you want." The plant is known in Berar as *Barbati* or *Jungli-methi*. *Methi* is the vernacular for Fenugreek (*Trigonella Fœnum-græcum*) a plant of the same natural order.

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in Bombay and Berar. (A. H. Church.)

INDIGOFERA SP.

The following is Professor Lyon's analysis, *Vegetable Materia Medica of Western India*, second edition, p. 891 :—

CHEMICAL
COMPOSITION.Analysis by
Professor
Lyon.

	Average cereal.	Average pulse.	Indigofera glandulosa.
Water	11.62	10.00	8.91
Fat	3.00	3.50	...
Albuminates	9.12	25.06	24.25
Carbo-hydrates	71.26	51.30	48.21
Cellulose	3.00	7.14	16.00
Ash	2.00	3.00	2.63
* Containing nitrogen per cent.	1.46	4.01	3.88
Nitrogen (grains per oz.)	6.38	17.86	16.97
Nutritive carbon (grains per oz.)	170.00	170.00	160.10
Percentage of nutritive value as compared with—			
Average cereal	100.00	...	...
Average pulse . . . . .	...	100.00	95.00

Professor Church reports as follows on the sample of *Indigofera glandulosa* :—

Report by
Professor
Church.

The seed of this wild indigo is rather larger than that of *Indigofera cordifolia* and much resembles that of *Indigofera linifolia*. 100 seeds of the analysed sample weighed $4\frac{1}{2}$ grains. These are the percentages obtained :—

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10337.

Water	8.2
Albuminoids (from total nitrogen)	31.9
Soluble carbo-hydrates (by difference)	46.7
Oil	2.2
Fibre	7.8
Ash	3.2

The nutrient-ratio is here 1 : 1.6 and the nutrient-value 83. The percentage of albuminoids by the phenol method was 29.32.

Indigofera linifolia, Retz.

Vernacular.—*Torki*, HIND. and PB.; *Bhangra*, BENG.; *Tandi Khode baha*, SANTAL; *Burburra*, *Pandhari pale*, *Bhangra*, *Torki*, BOMB.; *Pandhi*, NASIK; *Jawarich mal-mandi*, *Kaladgi*, BOMB.

I. 121-36

INDIGOFERA SP.

Wild Indigo Seed as a Famine Food.

CHEMICAL
COMPOSI-
TION.

Manner of
preparing
the seeds
for food in
the Bombay
Presidency.

Analysis by
Professor
Lyon.

Indigofera linifolia (vern. *Pandharphali*) is prepared for food in the following manner: The flour of the grain with the husk removed by pounding is made into bread. This bread has a somewhat bitter taste and is, therefore, eaten with vegetables or hot condiments. To make the bread palatable *Bajri* or *Jowari* is mixed with the grain before grinding in the proportion of 1 : 3. If bread be prepared of this grain without first pounding it and be eaten continuously for some days it causes swelling of the mouth or body.

Professor Lyon's analysis* is given below:—

	Average cereal.	Average pulse.	Indigofera linifolia.
Water	11'62	10'00	5'09
Fat	3'00	3'50	3'94
Albuminates †	9'12	25'06	33'29
Carbo-hydrates	71'26	51'30	20'05
Cellulose	3'00	7'14	33'90
Ash	2'00	3'00	3'73
† Containing nitrogen per cent.	1'46	4'01	5'37
Nitrogen (grains per oz.)	6'38	17'86	23'49
Nutritive carbon (grains per oz.)	170'00	170'00	130'10
Percentage of nutritive value as com- pared with—			
Average cereal	100'00	...	...
Average pulse . . . . .	...	100'00	76'50

* Vegetable Materia Medica, Western India, second edition, p. 391.

Professor Church's report on the seeds of **Indigofera linifolia** is as follows:—

The seeds of this common kind of wild indigo are eaten in times of scarcity and famine. They are a little smaller than those of **Indigofera glandulosa**. The percentages obtained were:—

Water	9'3
Albuminoids (from total nitrogen)	34'3
Soluble carbo-hydrates (by difference)	43'4
Oil	3'0
Fibre	6'5
Ash	3'5

The nutrient-ratio is here 1 : 1'47; the nutrient-value is 84. The phenol method showed 32'2 per cent. of albuminoids.

I. 121-36.

G. I. C. P. O.—No. 445 R. & A.—8-2-99.—2,225.—W. B. G.

Report by
Professor
Church.

Reg. No.
10386.

